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BY SIR D'ARCY POWER, K.B.E., LONDON

VII. C. H. MOORE, F.R.C.S., AND OPERATIONS FOR CANCER

CHARLES HEWITT MOORE may be looked upon as a pioneer of the modern operation to prevent recurrence after operation for cancer of the breast and so to cure the disease.

He was born at Plymouth on June 12, 1821, the second son of William Moore, who came of a well-known ship-building family. He was educated at the Plymouth Grammar School and was sent to London to study medicine on the advice of his uncle, Dr. Joseph Moore. Here he was apprenticed to Frederick Carpenter Skey, then Assistant Surgeon at St. Bartholomew's Hospital. Skey was a seceder from the medical school of the Hospital in one of those quarrelsome periods to which the London hospitals were accustomed during the nineteenth century. Skey was lecturing at the Aldersgate School of Medicine, and in 1842 Moore helped his master with the anatomy class. During his pupilage he acted as Clinical Clerk to Sir George Burrows, and in October, 1844, he was nominated House Surgeon by John Painter Vincent. He used to say in after life that to Burrows and Skey he owed his ability to think precisely and observe with accuracy. Burrows, on his side, said that Moore was one of the best of his clinical clerks, thoughtful, painstaking, and conscientious.

Moore took out courses at Vienna and Berlin for two years after his house surgeoncy ended in October, 1845, and on his return to England in 1847 was appointed at first Demonstrator and in the following year Lecturer on Anatomy at the Middlesex Hospital, holding the post for twenty years. He was elected Assistant Surgeon to the Hospital in 1848, and within a few months was appointed full Surgeon at the age of 27. He became Lecturer on Systematic Surgery in 1869 with Campbell de Morgan as his colleague, but the promotion came too late, for he had a cerebral hæmorrhage at the end of his first course of lectures and died after a prolonged illness on June 6, 1870.

Moore was in charge of the special cancer wards at the Middlesex Hospital for many years, and on May 28, 1867, he read a paper at the Royal Medico-Chirurgical Society giving the results of his experience. It is entitled, " On the

Influence of Inadequate Operations on the Theory of Cancer". He summarizes his conclusions in the following paragraphs, and in reading them it should be borne in mind that his contemporaries had almost given up operating upon cancer of the breast because their patients always had a recurrence within a short time. Moore says (*Med.-Chir. Trans.*, 1867, l, 245–80) :—

" Local recurrence of cancer after operations is due to the continuous growth of fragments of the principal tumour.

" Such recurrence may take place also in a residual part of the organ respecting which it cannot be asserted that it was cancerous at the time of the operation.

" Such recurrence may further happen in a structure adjoining a completely extirpated breast and on a comparison of cases may be held to be produced by disseminated fragments of the original tumour.

" The recurrent Cancer is subject, as well as due, to local conditions and especially adapts itself to the distribution of the absorbents. Its continuity with the first tumour may be traceable over half the chest, the pleura, and the glands from the neck to the loin or the inguinal region, and possibly also to the liver.

" After the removal of a portion of the breast the recurrent Cancer does not involve the remainder of the organ indiscriminately, but commences in that part of it which immediately adjoins the scar.

" The progress of recurrent Cancer after a partial removal of the breast is not exclusively organic, and does not even show a preference for that organ, but rather is centrifugal from the scar; and, when free in both directions, it tends toward the axilla earlier than to the residue of the breast.

" Cancer once established in either mamma, its primacy is supreme. When one breast has been wholly or partially removed, recurrent Cancer does not spring up as a new disease in the opposite breast, but on the same side as the original tumour. It may, nevertheless, be possible that a mammary Cancer having been wholly extirpated, Cancer may reappear in another part of the body, which other part may be the remaining breast. I have not met with such a case.

" It is not sufficient to remove the tumour or any portion only of the breast in which it is situated; mammary Cancer requires the careful extirpation of the entire organ.

" The situation in which the operation is most likely to be incomplete is at the edge of the mamma next the sternum.

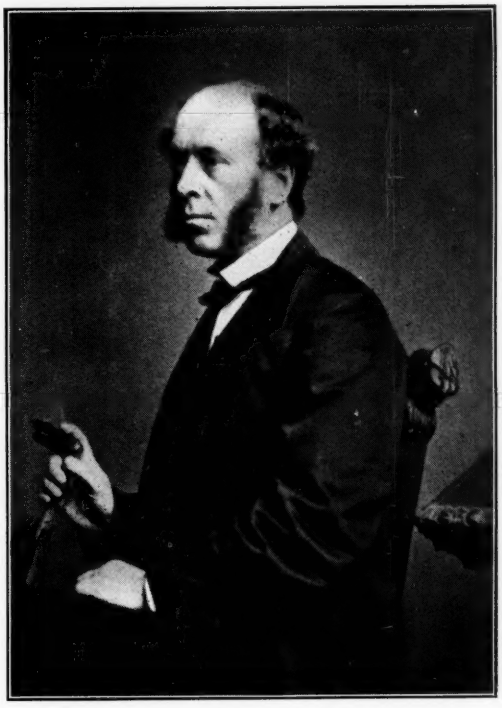
" When any texture adjoining the breast is involved in or even approached by the disease that texture should be removed with the breast. This observation relates especially to skin, to lymphatics, to much fat, and to pectoral muscle. The attempt to save skin which is in any degree unsound is of all errors perhaps the most pernicious, and whenever its condition is doubtful that texture should be freely removed. A broad scar, and the stretching and compression due to its subsequent contraction appear to be especially satisfactory.

" In the performance of the operation it is desirable to avoid not only cutting into the tumour, but also seeing it. No actually morbid texture should be exposed, lest the active microscopic elements in it be set free and lodge in the wound. Diseased axillary glands should be taken away by the same dissection as the breast itself, without dividing the intervening lymphatics; and the practice of first

roughly excising the central mass of the breast, and afterwards removing successive portions which may be of doubtful soundness, should be abandoned. Only by deliberately reflecting the flaps from the whole mamma, and detaching it first at its edge, can the various undetected prolongations of the tumour and outlying nodules be included in the operation. To parts suspected of disease but not capable of removal it is desirable to apply the chloride of zinc.

"The conclusions briefly stated, are partly theoretical and partly practical. The former are:—

"That the recurrence of Cancer is due to local conditions:



CHARLES HEWITT MOORE[4]

"That these conditions are not regional, so as to belong to structures out of continuity with the first tumour.

"That neither are they organic, whether as indiscriminately involving the residue of a mamma operated upon, or so as to be transferable to the second breast in consequence of the removal of that first affected;

"That, on the contrary, recurrent Cancer begins near the scar;

"That, when free in both directions, it tends toward the axilla earlier than to the residue of the breast;

"That, consequently centrifugal dispersion, not organic origin, determines the recurrence of Cancer.

"The practical conclusions are:—

"That Cancer of the breast requires the careful extirpation of the entire organ;

"That the situation in which this operation is most likely to be incomplete is at the edge of the mamma next the sternum,

"That, besides the breast unsound adjoining textures, especially skin, should be removed in the same mass with the principal disease."

These were hard sayings for a generation where an operation was always followed by suppuration and which looked to the cosmetic effect rather than to cure. The paper attracted so little attention that it was not thought worthy of notice by the medical journals and the discussion upon it was in the main adverse. Perhaps the personal element was a factor, for one of his contemporaries said of him that "Moore combined extreme caution with surprising rashness." It came under the notice, however, of Lister and of Mitchell Banks, who put it into practice in their own wards, and this was the beginning in England and Scotland of the modern operation for the cure of cancer.

TRAUMATIC HÆMANGIOMATOUS TUMOURS OF SKELETAL MUSCLE

By ROBERT MAILER
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VASCULAR tumours of striated muscle constitute a rare but well-recognized and interesting group. The last comprehensive survey of the literature by Jenkins and Delaney[7] in 1932 revealed 256 authentic cases, chiefly from continental sources, though cases have been described in this country by Gibb,[6] Bland-Sutton,[1] and Wakeley.[13] To Liston[8] belongs the credit of having described the first case as early as 1843. He called it an erectile tumour of the popliteal space, and it was found to be an angioma in association with the semimembranosus muscle.

Most of the cases reported have been described as cavernous angioma or hæmangioma of muscle, though frequently the terms capillary, venous, and arterial angioma are met with according as one or other of these vascular elements appeared to dominate the pathological picture.

Considered collectively, these tumours for the most part are non-encapsulated or only partially encapsulated, and at operation present infiltrating characters suggestive of sarcoma. Yet they are benign in their behaviour and rarely recur after removal. Their occurrence almost exclusively during the first three decades of life, taken in conjunction with the usually accepted views with regard to the etiology of angiomatous tumours elsewhere in the body, has strengthened the belief that these tumours are of congenital origin. The following case, therefore, seems worthy of presentation because the clear-cut history and the pathological findings pointed definitely to trauma as the exciting agent.

CASE REPORT

P. M., male, aged 21. This patient was first seen in consultation on Dec. 11, 1934. Complaint: swelling in the arm of two months' duration.

HISTORY.—Four months previous to consultation the patient had been involved in a motor accident. The light racing car in which he was travelling turned over, and his left arm was pinned under the weight of the car. There was severe bruising over the inner side of the arm from the anterior fold of the axilla to the elbow. Considerable pain was present for about ten days. Subsequent to this there was pain on swinging the arm on walking, and it was more comfortable to hold it in the sling position. A tender area remained about the middle of the upper arm on its inner and posterior aspect. Within three weeks of receiving the injury the patient resumed his usual activities, which included the breaking-in of young horses and participation in one or two junior steeplechases. He was conscious that his left arm tired readily, though he had no actual twinges of pain except when taking jumps.

Two months before consultation he became aware of a swelling about the size of a walnut on the inner and posterior aspect of his left arm. This had increased in size up to the time of examination.

ON EXAMINATION.—There was an ovoid swelling about the size of a hen's egg on the inner and posterior aspect of the left upper arm. Its long axis was in the long axis of the arm. It was smooth, firm, and elastic in consistence. The skin overlying it was normal in appearance and freely movable. The swelling was not attached to bone. It was movable to some

extent in a transverse axis, but not in a longitudinal, and it became more prominent and fixed when the extensor muscles were tightened. Its borders were poorly defined, and it had the feeling of an infiltrating rather than an encapsulated swelling. It was slightly tender.

PROVISIONAL DIAGNOSIS.—Fibroma of triceps muscle.

In view of the history of rapid growth and the infiltrating character of the swelling, which made it impossible to exclude sarcoma, operation was advised.

OPERATION.—The triceps muscle was exposed and an infiltrating tumour mass excised from the belly of the inner head. It was necessary to sacrifice a considerable bulk of muscle to get clear of the growth. Bleeding was very free, but was readily controlled. The wound was closed without drainage. Healing was uninterrupted, and when the patient was seen three months later there was no demonstrable functional impairment of the arm.

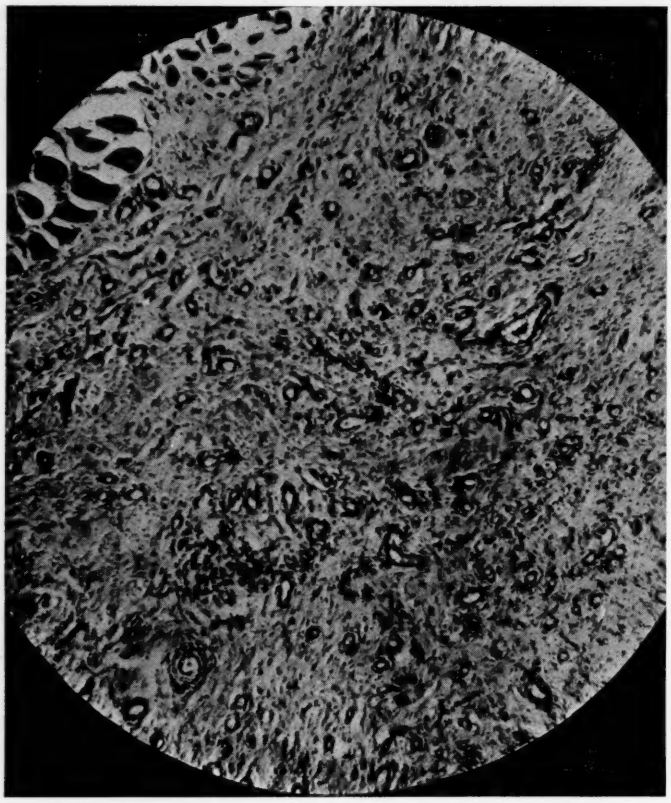

FIG. 188.—Low-power microphotograph of angiomatous tumour showing numerous capillaries in a young connective-tissue stroma. At the upper margin the tumour is seen extending between groups of muscle fibres. (Hæmatoxylin and eosin.) (× 110.)

PATHOLOGICAL REPORT.—The specimen is an ovoid mass of tissue about 6 cm. by 5 cm. with attached muscle fibres. On section there is a large central cavity with smooth wall about 1·5 cm. by 1·5 cm., containing a partially organized blood-clot. The remaining tissue sectioned is yellowish-white or greyish-white in colour, fairly firm nearer the central cavity, but softer nearer the periphery.

Microscopic Examination.—The area immediately surrounding the central cavity consists of organizing fibrin with clumps of red blood-cells in a matrix of young fibrous connective tissue. One or two fragments of degenerated muscle fibre are still recognizable. Sections of the peripheral portion of the tumour show an enormous vascular overgrowth involving chiefly capillaries (*Fig.* 188), but also in areas a very extensive overgrowth of the smaller muscle-walled arteries is seen (*Fig.* 189). These arteries have thickened walls, and some of

them contain thrombi. Here and there are large irregular vascular spaces of the cavernous type. These are lined by a single layer of endothelial cells and have a wall of fibrous connective tissue.

These vascular elements are found in a loose fibrous connective-tissue stroma. Capillary hæmorrhages are frequent in the border zone between tumour and intact muscle fibres (*Fig.* 190). The angiomatous formation is seen extending between muscle fibres or groups of muscle fibres. The latter are in various phases of degeneration (*Fig.* 191). Some fibres show only a loss of staining reaction; others show their sarcoplasm shrunken and fragmented, while in adjacent areas the fibres have disappeared and are replaced by a hyaline matrix suggestive of the Zenker type of coagulation necrosis. A few fibres show proliferation

FIG. 189.—Low-power microphotograph showing in addition to numerous capillaries arterioles with thickened walls. (Hæmatoxylin and eosin.) (× 110.)

of sarcolemma nuclei and the formation of 'muscle tubes' such as have been described by Waldeyer,[14] Weber,[15] Dawson[14] and others in their studies in muscle regeneration. The vascular overgrowth always follows the endomysial trabeculæ and never penetrates the sarcolemma of the muscle fibre. There is no encapsulation anywhere.

PATHOLOGICAL DIAGNOSIS.—Mixed capillary and arterial angioma.

A SHORT SURVEY OF THE LITERATURE

A study of the 256 cases reported in the literature shows that while angiomatous tumours of muscle may vary widely as regards size, consistency, rate of growth, etc., there are certain features common to the majority. These are summarized below.

Age Incidence.—Of the reported cases 80 per cent occurred before the age of 20, and 95 per cent before the age of 30, so that they are tumours of childhood or early adult life.

Situation of the Tumour.—The lower extremity was the most common site, especially the thigh (107 cases). The quadriceps extensor was the muscle most frequently involved. The upper extremity, especially the biceps and triceps muscles, accounted for 64 cases.

Clinical Features.—A tumour mass, round or ovoid, varying in size from a nut to an egg, growing slowly and at first painlessly, was the common finding.

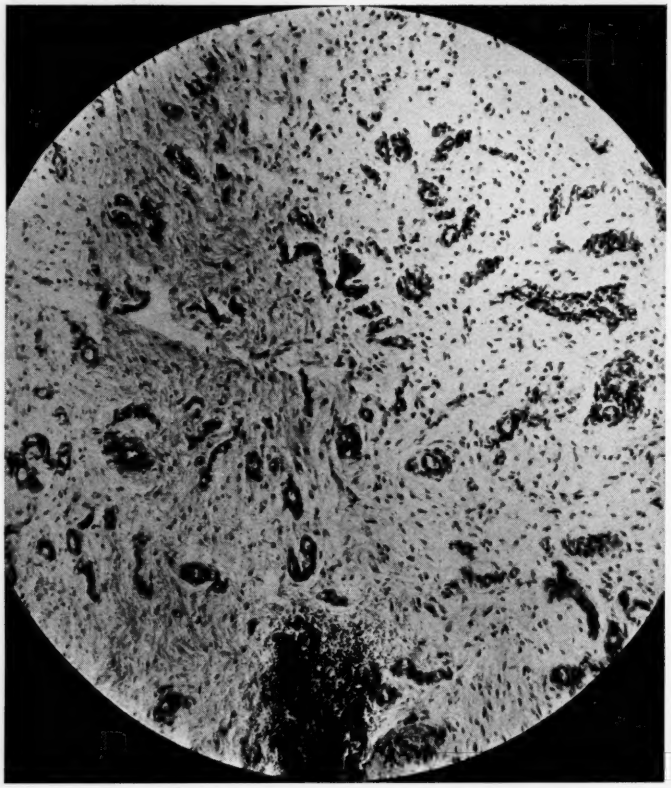

FIG. 190.—Low-power microphotograph showing numerous capillaries with proliferative changes round the walls. A hæmorrhage is also seen in the lower part of the section. (Hæmatoxylin and eosin.) (× 110.)

The tumour was usually diffuse and often tender. The consistency varied: in 64 cases it was described as soft, but in 55 cases it was hard, and in 30 elastic. Sometimes it could be reduced in size by pressure or by elevating the limb. The overlying skin was almost invariably normal in appearance and freely movable over the tumour. Pain usually developed at some time in the course of the disease. Some functional impairment was frequently present when the tumour was situated in an extremity, and not uncommonly there was actual deformity.

Diagnosis.—This was made previous to operation in only 21 cases. In soft semi-fluctuant tumours resembling abscess, the diagnosis was made by the exploring needle withdrawing blood. Occasionally an X-ray photograph demonstrated phleboliths as in Wakeley's case.

Pathological Features.—The tumour in section was often described as bluish or reddish, but sometimes as greyish or yellowish-white. Blood cysts were noted in five cases, and sometimes nodular areas due to phleboliths.

Under the microscope the tumour was described as made up of vascular elements in a connective-tissue stroma. The most frequent vascular formation was the cavernous space. Arterioles with thickened walls were often present, and often capillaries. The latter were sometimes the predominating feature. Thrombi in

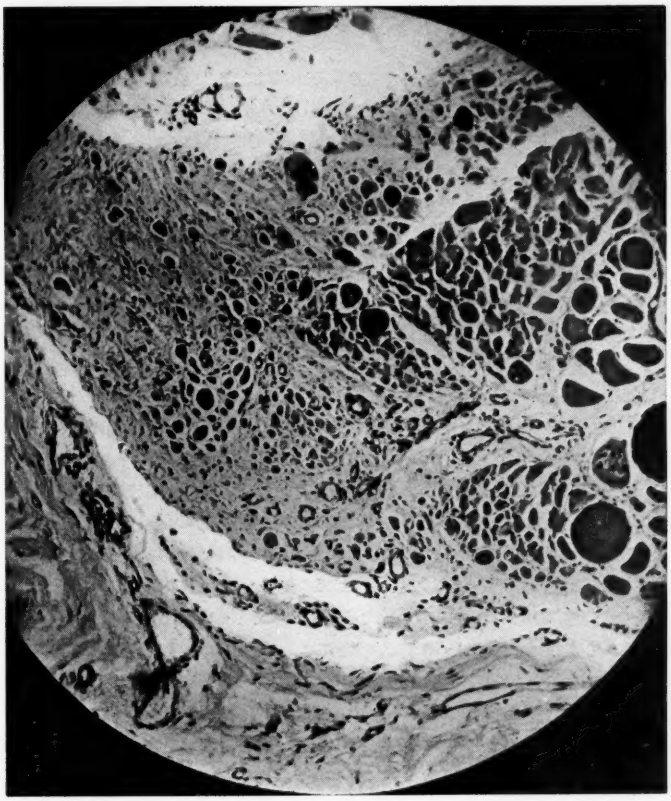

FIG. 191.—Low-power microphotograph of degenerating muscle fibres showing change in staining reaction and proliferation of sarcolemma nuclei. The angiomatous formation is seen extending between the groups of degenerating fibres. (Hæmatoxylin and eosin.) (× 110.)

varying stages of organization were frequently present in the lacunæ or large vessels. The stroma varies in its cellular elements, and in six cases the possibility of sarcoma was considered, the fibroblastic proliferation being so marked. Round-celled accumulations were often present. In the stroma were remnants of striated muscle in some stage of degeneration. In the central part of the tumour the degenerative changes were usually complete, but towards the periphery the fibres were better preserved and even apparently normal.

Etiology.—There has been some difference of opinion between pathologists as to whether angiomata constitute true neoplasms. Ribbert[10] favoured the Cohnheim theory that angiomata develop from embryonic rests. Virchow[12] suggested that these tumours arose from the effect of local irritation on imperfectly

formed blood-vessels. On the other hand, Rokitansky[11] considered that they represented a simple hypertrophy of the vascular elements and not a neoplastic overgrowth. Trauma as a factor has been stressed by Lowenthal and Pilzer.[9]

In the 256 cases of muscle angioma reviewed in the literature trauma was mentioned as a possible factor in 43 (17 per cent). Yet the early age incidence has inclined most authors to regard the congenital factor as of supreme importance, with trauma as an occasional secondary exciting agent.

DISCUSSION

In the case reported here there is no doubt that trauma was the etiological factor at work. The clear-cut history and the pathological appearance of the tumour with central organizing blood-clot allows of no other explanation. Angiomatous tumours, apart from the vascular nævus, are not common in any situation, and their occurrence relatively often in muscle suggests something more than a developmental factor. Skeletal muscle is exposed not only to external trauma, but also to trauma dependent upon its inherent contractile power. Cases of complete rupture of muscle due to strong muscular contraction are occasionally met with, especially in the biceps, quadriceps, and rectus abdominis. Such cases call for immediate operative treatment, and as far as I am aware are never followed by tumour overgrowth. Again, one of the commonest causes of injury to muscle is a fractured bone, yet angiomatous formations in muscle following fracture are not met with. In the case of complete rupture of muscle, and also in association with injury due to fracture, rest and immobilization are ensured. It is, however, with minor traumata of muscles that conditions may be different. Here a few fibres only may be torn. A blood-clot forms and the torn fibres retract. Granulation tissue fills the gap, and this may be modified by several factors. In the first place muscle fibres have a limited power of regeneration, and this is more manifest in younger subjects. The exciting agent in the reactive processes is a substance furnished by the bruised muscle fibres, and Dawson[4] has pointed out in his studies on muscle repair that the endothelial proliferation is most intense. Though it is impossible for muscular tissue to regenerate and bridge a gap of more than 3 or 4 mm. under the most favourable conditions, it appears reasonable to suppose that the reactive processes develop on a scale commensurate with this possibility. The relatively large blood-clot due to the retraction of torn muscle fibres also offers a most favourable medium for excessive cell proliferation. This might reasonably explain the angiomatous nature of the granulation tissue, but it does not offer an explanation of the infiltrating nature of the process and the absence of self-limitation. This, however, can be explained on the basis of the repeated traumata to which the young vascular granulation tissue is exposed owing to muscular contraction. Capillary hæmorrhages develop. Muscle fibres at the periphery of the tumour are separated, damaged, and undergo degeneration and the cycle of reactive changes is repeated. On this basis the tumour is to be regarded more correctly as a soft non-encapsulated fibroma showing special angiomatous features dependent on its situation in highly specialized contractile tissue, damage to which is associated with a more intense endothelial proliferation than is met with in any other tissue. Moreover, this highly vascularized tissue in virtue of its situation in muscle cannot fail to be subjected to strains, resulting in hæmorrhages, which account for the progressive enlargement.

It is not contended that from a study of a single case one can generalize on the etiology of these tumours. They do not all conform to the same type, and in some a simple saccular and tubular dilatation of pre-existing veins would seem to explain their origin. For example, the angioma of the gracilis muscle removed by Stonham[2] and now in the Westminster Hospital Museum resembles a widespread varix. On the other hand, from a study of the case presented here, together with the reports of many similar cases in the literature, there are reasonable grounds for supposing that trauma is the important factor in their development and that there is no necessity for postulating a congenital factor universally. Some cases occurring in new-born children would appear almost certainly to be congenital, though here again birth injuries might have to be considered. Lastly, on this hypothesis, the occurrence of these tumours in young subjects is explainable on the basis that the latter are more exposed to trauma, together with the fact that the younger the patient the greater the potentiality and the intensity of the regenerative process.

SUMMARY

A case of hæmangioma of the triceps muscle in a man of 21 is described. The tumour was non-encapsulated, and consisted of dilated capillaries and thick-walled arterioles in a young fibrous connective-tissue stroma. The history and pathological appearances afforded strong evidence that the tumour was traumatic in origin. A short survey of the 256 cases previously reported in the literature is appended, and the importance of the traumatic factor as against the congenital factor is stressed. Based on a study of the present case, an explanation is given how trauma acts in the production of these hæmangiomata of muscle.

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TWO CASES OF HÆMANGIOMA OF VOLUNTARY MUSCLE: WITH A BRIEF REVIEW OF THE LITERATURE

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IN view of the rarity of these tumours the following two cases seem worthy of report.

Case 1.—Unmarried woman, aged 24. First seen in October, 1932, complaining of pain and swelling of the left leg. She had been in hospital seven years previously, when 'varicose veins' had been removed from the left calf; and again in 1929, when she had been unavailingly treated by massage for the same pain and swelling. The calf was swollen fairly uniformly for about 2 in. below the line of the knee-joint to about 1½ in. above the ankle; the two scars of the varicose vein excision were visible on the back of the calf; the limb was neither œdematous nor tender. An area of greater resistance suggesting a calcified plaque or fibrous node about the size of a florin could be felt on the inner side of the calf around the centre. There was no abnormality in any of the limb bones, and the X-ray taken during her last visit to hospital was negative.

A provisional diagnosis of pseudo-elephantiasis or muscle angioma was made and exploratory operation advised.

OPERATION.—This was done under general anæsthesia. An incision about 2 in. long was made over the palpable mass down to the deep fascia. Here was found a thickened area of fascia surrounded by thin-walled dilated veins. The deep fascia was opened and a mass of fibro-fatty and angiomatous nature revealed between the deep and superficial muscles, and partly infiltrating the latter. The tumour readily shelled out except where it had infiltrated the soleus, which was extensively replaced by tumour tissue, and the gastrocnemius, which was only slightly involved. To expose the mass it was necessary to extend the incision to ½ in. behind the internal malleolus below, and ½ in. below the line of the knee-joint above. The mass extended above almost right across the leg, leaving very little normal soleus outside it, while below it tapered to about the thickness of the little finger and was easily shelled out from the connective tissue. The muscle adjacent to the palpable edge of the tumour was yellowish and not contractile. The tumour was removed by enucleation where possible, and cutting through healthy, contractile muscle where no line of cleavage was evident. The muscles were reconstituted as well as possible and the wound was sutured, a rubber-dam drain being left beneath the deep fascia. Convalescence was quite uneventful.

I had an opportunity of re-examining this patient last August, over twenty months after operation; there is nothing to suggest recurrence, and the muscle of the calf has hypertrophied so that there is no significant difference in the circumference of the two legs.

PATHOLOGY.—After preservation in alcohol the specimen measured 9½ in. in length and 2½ in. at its widest part. To the naked eye it appeared to be for the most part fibro-fatty tissue, well encapsuled, with areas of dilated vessels most numerous towards the margin of the tumour where it was infiltrating the muscle. Microscopically these observations were confirmed; the vascular areas were typically angiomatous in structure. Where the tumour was invading the muscles, the endothelial cells were especially numerous, and the adjacent muscle fibres were degenerated, appearing relatively opaque and having lost their transverse striation. The tumour seemed to have a more vascular spreading margin which destroyed, and then replaced, the muscle, and was in its turn replaced by fibro-fatty tissue containing angiomatous islets. Unfortunately the original slides were thrown out in the pathological laboratory, and as the tumour had been hardened in alcohol for such a long time it was not possible to prepare a second set of slides for microphotographs.

Case 2.—Boy, aged 12 years. About three years previously his mother noticed a swelling about the centre of the dorsal region to the right of the middle line: he was admitted to a hospital, where a tentative diagnosis of Pott's caries was made. Three aspirations of the mass yielded only blood, and his X-ray showed no bony changes; he was seen by several practitioners and ultimately provided with a spinal jacket, which he had worn for over two years, when he was referred to me by the T.B.M.O. He presented then a swelling the size of a duck's egg in the mid-dorsal region just to the right of the middle line and apparently in the erector spinæ. His mother stated that the mass had increased only slightly in size in the preceding two years. The skin over the swelling looked normal and was not adherent; the mass was resilient, well-defined, and irreducible, and dull on percussion; no sounds were heard on auscultation over it; there was no clinical evidence of Pott's disease. On aspiration pure blood was obtained.

A provisional diagnosis of hæmangioma of the erector spinæ was made, though the alternatives of sarcoma, spinal caries, and hernia pulmonis were not absolutely excluded.

OPERATION.—Under ether anæsthesia an incision was made over the mass and the dorsal fascia opened; a whitish mass not adherent to the fascia was exposed. This was easily shelled out from the erector spinæ at the sides, but there was no line of demarcation between tumour and muscle above and below, thus necessitating removal of some muscle with the growth. As in *Case* 1, the wound was closed with a small dam drain and convalescence was uneventful.

I saw this boy seventeen months after operation and found his back perfectly healthy.

PATHOLOGY.—The tumour was about the size of a duck's egg and greyish-white in colour; on section it showed numerous purplish islets about ⅜ in. in diameter. Microscopically these islets were seen to be composed of large blood-spaces with an endothelial lining, and rather loose fibrous tissue; the remainder of the tumour consisted of less vascular tissue with a more dense connective-tissue stroma (*Fig.* 192). The tumour was therefore a fibro-hæmangioma.

FIG. 192.—Microscopical appearance of muscle angioma.

DISCUSSION

Hæmangioma of muscle was first described by Muscatello (1894). A closely detailed review of the cases reported up to date was glven by Jenkins and Delaney (1932); at the time their paper was written 256 such tumours had been described. I have been able to find references to two further cases by Rocher and Uzac (1931), and Truesdell (1931), bringing the number of muscle angiomata described up to

260. (This does not include cases described by Bartoli (1932), as his paper was unfortunately inaccessible to me.)

Clinical Signs.—The main signs evidenced by such tumours are: a mass usually demonstrably adherent to the muscle, though this may be masked by the overlying soft tissues; the mass is of varying consistence, depending on the proportion between fibrous tissue and vessel spaces, from moderately firm to so fluctuant as to support the diagnosis of abscess, though the tumour is only rarely adherent to the skin. On aspiration blood is obtained, but this *per se* does not exclude sarcoma or cyst from the diagnosis. Radiologically phleboliths were found in 34 cases out of 63 so examined (they were not found in my two cases, both of which had been radiographed before they were seen by me).

Other symptoms described are in approximate order of frequency: (1) *Pain*, which may be constant but is generally increased on exertion; (2) *Limitation of movement* due to mechanical interference by the tumour mass; (3) *Loss of function* or *deformity* due to the replacement of muscle tissue by the angioma, as in *Case* 1; (4) *Pressure symptoms* due to pressure on vessels or nerves causing (*a*) hypertrophy of a limb, (*b*) anæmic atrophy, (*c*) diminished pulsation in the vessels distal to the lesion, or (*d*) referred pain; (5) Rarely the skin has been described as *bluish* in colour (seven cases) or *containing dilated veins* (five cases and *Case* 1); (6) *Calcification* of part of the tumour was noted in four cases, and *pulsation* in four others; (7) A *buzzing* sound on auscultation was described in one case; (8) X-rays give mainly negative information, though the finding of *phleboliths* in a suspicious case renders more probable the diagnosis of angioma.

Diagnosis.—On surveying the literature one is struck by the rarity of correct diagnosis of these tumours; a correct pre-operative diagnosis was made in only 12 per cent, while it was only considered as an alternative diagnosis in $2\frac{1}{2}$ per cent, including my two cases. Such growths must often escape recognition owing to the regrettable disuse into which exploratory incision has been pushed by perhaps excessive reliance on radiological and laboratory aids to diagnosis.

Table I gives a survey of the diagnoses: (1) In the 91 cases in which a definite pre-operative diagnosis was made; and (2) In the 34 cases in which an alternative diagnosis was made. In many of the reported cases no pre-operative diagnosis was mentioned.

Table I.—PRE-OPERATIVE DIAGNOSIS

	DEFINITE	ALTERNATIVE		DEFINITE	ALTERNATIVE
Abscess, acute	1	—	Lipoma	11	4
Abscess, chronic	6	3	Myoma	2	—
Aneurysm	1	—	Myositis	1	1
Angioma	31	6	Neoplasm, benign	4	2
Angiofibroma	1	—	Neoplasm, malignant	2	—
Angiolipoma	1	—	Neuroma, false	1	—
Angiolymphoma	4	—	Neuroma, true	5	1
Arthritis	1	2	Osteomyelitis	2	1
Bone tumour	1	—	Pelvic cellulitis	1	—
Bursitis	1	—	Phlebitis	1	—
Club-foot	1	—	Sarcoma	2	3
Cyst (including dermoid)	7	6	Synovitis	—	1
Epithelioma	1	—	Tuberculosis of muscle	1	1
Ganglion	1	—	Tuberculous glands	1	—
Gumma	1	2	Tuberculous spine	1*	—
Hernia, epigastric	—	1	Varix	2†	—
Hernia, parumbilical	1	—			

* *Case* 2. † Including *Case* 1.

Pathology.—The noteworthy points in the pathology of these tumours are: (1) That while clinically benign, metastases never occurring and recurrence being very rare (and then most probably due to incomplete removal), they may exhibit a peculiar local malignancy, infiltrating the muscle, which degenerates before them; and (2) The tendency towards partial replacement of the originally angiomatous structure by fibrous or fatty tissue in the centre.

Table II shows distribution as gleaned from a study of the literature.

Table II.—Muscular Distribution of Angiomata According to Regions

Head—		Flexor carpi ulnaris	3
Temporal	3	Pronator radii teres	3
Masseter	15	Pronator radii quadratus	1
Orbicularis oculi	2	Extensor carpi radialis longus	1
Rectus internus	1	Extensor carpi radialis brevis	1
Inferior oblique	11	Extensor longus pollicis	2
Buccinator	1	Extensor carpi ulnaris	2
Neck—		Supinator longus	5
Splenius	1	Thenar muscles	8
Sternomastoid	4	Hypothenar muscles	3
Depressors of tongue and lower jaw	1	*Lower Limb*—	
Chest—		Ilio-psoas	2
Intercostals	2	Gluteus maximus	5
Abdomen—		Gluteus minimus	2
General	4	Gluteus medius	4
External oblique	3	Gemelli	2
Internal oblique	1	Quadriceps	19
Rectus	6	Vastus internus	17
Back—		Vastus externus	5
Erector spinæ	10	Crureus	—
Quadratus lumborum	6	Rectus femoris	6
Sacrospinalis	1	Sartorius	2
Upper Limb—		Adductor longus	1
Trapezius	11	Semimembranosus	10
Latissimus dorsi	13	Semitendinosus	5
Serratus posterior inferior	3	Gracilis	3
Rhomboideus major	1	Biceps femoris	12
Rhomboideus minor	2	Soleus	11
Infraspinatus	2	Gastrocnemius	21
Pectoralis major	8	Tibialis posticus	1
Serratus magnus	5	Flexor longus digitorum	3
Deltoid	7	Flexor longus hallucis	4
Teres major	2	Tibialis anticus	2
Subscapularis	1	Extensor longus digitorum	1
Coraco-brachialis	1	Extensor brevis digitorum	1
Biceps	7	Extensor longus hallucis	1
Brachialis anticus	1	Extensor brevis hallucis	1
Triceps	16	Peroneus longus	1
Anconeus	1	Peroneus brevis	2
Flexor-pronator group	5	Peroneus tertius	1
Flexor sublimis digitorum	7	Plantaris	1
Flexor profundus digitorum	—	Sole muscles	3
Flexor longus pollicis	2	*Tongue*	2
Flexor carpi radialis	6		

Insufficiently Localized

Forearm	4	Arm and hand	1
Lower limb	1	Foot and leg	1
Upper limb	1	Thigh	1
Deep neck muscles	1	Leg	1

It would appear from a study of *Table II* that no muscle or muscle group is

per se especially liable to angioma, but that predominance of these tumours as reported in any particular region is explicable by the actual mass of muscle and its accessibility for examination.

Age Distribution and Recurrence.—The age distribution is shown in *Table III.*—

Table III.—Age Distribution of Angioma of Muscles

Ages	Cases
0– 5	7
6–10	15
11–15	24
16–20	35
21–25	31
26–30	12
31–35	8
36–40	4
41–45	4
46–50	2
51–55	1
66–70	3

It is thus seen that these are growths of early life, 62½ per cent occurring between 11 and 26 years of age.

The recurrence rate as found in the literature works out at 6 per cent, but this is usually, if not always, explicable by inadequate excision. My two cases are free from recurrence over two years after operation.

Treatment.—The obvious treatment is excision, a small margin of muscle being removed if the tumour does not shell out readily. Ligation of vessels, X rays, radium, and injection of sclerosing solutions have all been utilized, but are in general inefficacious.

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THE HISTORY OF PLASTER-OF-PARIS IN THE TREATMENT OF FRACTURES

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A THOUSAND years before Joseph became Governor under Pharaoh the Egyptians were using stiffened linen for splinting. It is probable that embalmer's bandage was linen, and gum or plaster the stiffening agent.[1-3]

Hippocrates,[4] who wrote about 350 B.C., used bandages " smeared with cerate and rosin " for fractures of the lower limb.

> Two strong men will suffice by making extension and counter-extension. Extension must naturally be made straight in a line with the leg and thigh, whether on account of fracture of the bones of the leg or of the thigh. And in both cases they are to be bandaged while in a state of extension.
>
> You should apply the bandages while the limb is in a stretched position . . . and the end of the bandage should be placed over the fracture . . . the bandages would be broader and larger and more numerous in the case of the leg than in that of the arm. And when it is bandaged it should be laid upon some smooth and soft object, so that it may not be distorted to the one side or the other, and that there may be no protrusion of the bones either forwards or backwards, for this purpose nothing is more convenient than a cushion.
>
> When the thigh-bone is broken, particular pains should be taken with regard to the extension that it may not be insufficient, for when excessive, no great harm results from it. For, if one should bandage a limb while the extremities of the bone are separated to a distance from one another by the force of the extension, the bandaging will not keep them separate, and so the bones will come together again as soon as the persons stretching it let go their hold for the fleshy parts being thick and strong, are more powerful than the bandaging.

To fractures of the nose[5] he applied a waxed compress of wheaten flour, to which manna of frankincense or gum might be added.

Rhazes,[6] an Arabian physician born A.D. 860, tells of an improvement.

> But if thou make thine apparatus with lime and white of egg it will be much handsomer and still more useful ; in fact, it will become as hard as stone and will not need to be removed until the healing is complete.

The practice of the Middle Ages, however, rather followed Hippocrates, and bandages stiffened by dipping in egg albumen and solidifying pastes were used. In England the method was popularized by William Cheselden,[7] surgeon and anatomist, who lived from 1688 to 1752. In his *Anatomy of the Human Body* he wrote :—

> I thought of a much better bandage, which I had learnt from Mr. Cowper, a bone-setter at Leicester, who set and cured a fracture of my own cubit when I was a boy at school. His way was, after putting the limb in a proper posture, to wrap it up in rags dipped in the whites of eggs, and a little wheat flour mixed ; this drying, grew stiff, and kept the limb in good posture. And I think there is no way better than this in fractures, for it preserves the position of the limb without strict bandage, which is the common cause of mischief in fractures.

The functional result in Cheselden's own arm[8] was evidently excellent, for, in younger days he was a keen boxer, and at the height of his professional career his

manual dexterity was such that he completed the operation of cutting for stone in sixty-eight seconds. Cheselden recommends making the apparatus thin over the crest of the tibia " so as to facilitate cutting it up and tightening it when it becomes loose ". A picture of the apparatus is reproduced in the *Robert Jones Birthday Volume*.[9] Sixteen years later Le Dran[10] introduced similar methods in France, stiffening his apparatus with white of egg, vinegar, and powder of Armenian bole (an earthy mineral resembling clay), or with starch or plaster. Percivall Pott,[11] in his *Remarks on Fractures* (1769), makes no mention of any hardening dressing, but enunciates an important principle when he insists that in splinting fractures the joint above and the joint below the fracture must be immobilized. He advises that dressings and splints be applied firmly about joints but loosely over the fracture.

Meanwhile in Arabia the use of plaster-of-Paris had probably continued with little change. This was made known in Europe by Mr. Eton,[12] who had been British Consul in Bassora. In 1798 he published *A Survey of the Turkish Empire*, in which there is the following interesting reference to the treatment of fractures.

> I saw in the eastern parts of the Empire a method of setting bones practised, which appears to me worthy of the attention of surgeons in Europe. It is by inclosing the broken limb, after the bones are put in their places, in a case of plaster-of-Paris (or gypsum) which takes exactly the form of the limb, without any pressure, and in a few minutes the mass is solid and strong. . . . This substance may be easily cut with a knife, and removed, and replaced with another. If, when the swelling subsides the cavity is too large for the limb, a hole or holes being left, liquid gypsum plaster may be poured in, which will perfectly fill up the void, and exactly fit the limb. A hole may be made at first by placing an oiled cork or bit of wood against any part where it is required, and when the plaster is set, it is to be removed. There is nothing in gypsum injurious, if it be free from lime; it will soon become very dry and light, and the limb may be bathed with spirits, which will penetrate through the covering. I saw a case of a most terrible compound fracture of the leg and thigh, by the fall of a cannon, cured in this manner. The person was seated on the ground, and the plaster case extended from below the heel to the upper part of his thigh, whence a bandage, fastened into the plaster, went round his body.

A similar method, perhaps as ancient, was in use in India. Sir George Ballingall[13] tells :—

> The practice of enveloping fractured limbs in splints and bandages, without undoing them for weeks together, is akin to that followed by the natives of India, of inclosing fractured limbs in moulds of clay. Of the successful result of this practice I remember a remarkable instance in the case of a little boy who was brought into my tent one morning, having been run over by a waggon on the line of march, and having sustained a severe compound fracture of the leg. I was preparing to amputate this boy's limb when his parents came in and carried him away to the potter in an adjoining village, who enveloped the leg in clay, and I believe finally cured the patient.

Napoleon's surgeon, Baron Larrey, in the Egyptian campaign of 1798, used fixing agents of the Cheselden kind in his " appareil inamovible.[14]

> This apparatus consisted of many-tailed bandages; of roller bandages impregnated with a hardening liquid made of a mixture of camphorated alcohol, lead lotion and white of egg in water—these wrapped round the limb; and strips of leather; of two cylinders of straw sewn strongly with string and serving as packing, etc.; the whole being saturated with the hardening fluid. This bandage becomes hard as it dries, and is left in place until healing occurs, unless there is some grave complication.

Hubenthal[15] (1816) used equal parts of plaster-of-Paris and ground-up blotting paper. He greased the limb to prevent the plaster adhering to it and split the plaster down the sides, making the anterior and posterior halves interlock in rather

an ingenious way. With a spatula he spread his mixture over the posterior part of the limb and trimmed the edges of this half-mould while still soft, and cut notches in it. He next greased this serrated edge and proceeded to make the anterior half-mould. He adapted the method also to fractures of the upper limb, and even to those of the clavicle.

In 1828 Koyl and Kluge, followed by Dieffenbach, attempted to generalize the use of plaster-of-Paris at the Charité Hospital in Berlin. Their method was to rest the limb in a wooden box, into which liquid plaster-of-Paris was then poured until the limb was almost, but not quite, covered. This allowed the fracture site to be kept under observation without detracting from the solidity of the plaster. When the plaster had set, the wooden box was removed, for its sides were fixed together merely with hooks, while its inner side was greased. Dieffenbach applied plaster only when the swelling had subsided. This " plâtre coulé " method closely resembles that of the Arabian physicians described above.

The use of gums and pastes was brought to its greatest perfection in Brussels by Seutin, Senior Medical Officer of the Belgian Army about 1834, and this method remained the most popular until the establishment of the plaster-of-Paris bandages. Seutin's writings are rather spoiled by an undercurrent of controversy. He is at great pains to establish his claim to having invented the method. Plagiarism is the charge made against M. Velpeau, of Paris, who made a small modification in the technique by substituting dextrin for starch. But full recognition of Seutin's originality was made in a letter written by Velpeau in 1837 and reprinted in Seutin's book. In fact, Seutin claimed originality for several features that had been used previously—for example, the splitting of the case down the front for inspection of the limb and for tightening the plaster. Such inspection dates from the Arabians, the tightening from Cheselden. Later Seutin stressed his contention that plaster-of-Paris was a poor substitute for his " bandage amidonné ".

He did, however, make a great advance in appreciating the disadvantage the patient suffered by being confined to bed throughout the period of healing.

> On n'avait pas encore bien compris que l'immobilité du corps, tant recommandée par les auteurs comme auxiliaire des autres moyens curatifs, n'est qu'un véritable pis-aller qu'il faut plutôt eviter que prescrire ; on n'avait pas encore osé dire que la consolidation de la rupture osseuse est d'autant plus sure et prompte que le blessé se livre a plus de mouvements, et oublie, pour ainsi dire, son affection pour reprendre une partie de ses occupations ordinaires.
>
> La déambulation ne peut occasionner ni accident ni déplacement des fragments : . . . en permettant au malade de se distraire de se retremper au grand air, au lieu de rester cloué sur son lit, elle a la plus heureuse influence sur la formation et la consolidation du cal.

With Cheselden's, Larrey's, or Dieffenbach's apparatus it was not possible for the patient to leave his bed. Seutin's book has a picture of a man whose fractured leg is protected by a light, strong appliance of starch bandages and kept clear of the ground by a strap round his neck ; he is going about on crutches and the sound leg, the foot of which wears a high boot.

This book gives details of Seutin's technique. The deformity was reduced and then the limb fixed as follows. The bony prominences were padded with wool, and then a roller bandage was methodically and firmly applied to cover the limb, reverses and creases being avoided. Over this, bandages soaked in starch were wound, with a cardboard splint, softened by wetting, incorporated on each side of the limb. The digits were left projecting from the apparatus so that interference

with the blood-supply by pressure could be detected. The bandages were applied firmly, rather to prevent swelling of the limb than actually to compress it.

When the cast had fully hardened it was split down the front, so that it could be hinged open throughout its whole length. For doing this he introduced a special pair of scissors, which to-day appears in instrument-makers' catalogues as ' Seutin's plaster scissors '—a deviation to a use which the originator would have condemned. If the limb was found to be in satisfactory condition, the case was re-united by a starch bandage; if it had become loose owing to subsidence of swelling, a strip beside the slit was first excised. If the limb required much local treatment, the cast could be split posteriorly as well, so as to be converted into two lateral halves, or, if the damaged part could be better approached that way, the splits could be made down the sides, so as to make an anterior and a posterior half. If the joints included in the cast tended to become stiff after long fixation, the case was temporarily removed and movements were performed while the limb was carefully held by assistants. To such an apparatus he gave the cumbrous name of ' amovo-inamovible ', meaning that the apparatus when it had hardened was immovable, but that after splitting it could be temporarily removed to allow treatment of joints and soft parts. In fractures of the upper limb the patient was never confined to bed unless there was some grave complication. In the lower limb, the patient got up on crutches after the third day. The great disadvantage of the starch apparatus was that it took about two days to harden. During this time Seutin assured its rigidity by ' atelles de précaution ' fixed over it. He was looking for a substance which would cause the bandage to solidify instantaneously, " persuadé d'ailleurs que tôt ou tard on parviendrait à cette découverte, qui du reste ne changerait rien aux principes de ma méthode ". But plaster-of-Paris did not commend itself to him for this purpose.

In 1852 Matthysen,[16] a medical officer in the Dutch Army, published a pamphlet on the use of plaster-of-Paris for treating fractures. The finely-powdered plaster, he writes, is rubbed with the hand into strips of coarse-meshed cotton material lying on a table. The strips are then loosely rolled into bandages. He insists particularly that the cotton must be entirely free from starch and dressing, which substances retard setting, a precaution which subsequent users of plaster bandages have not always observed. He tells that his method was invented especially for convenient (' cito, tuto, ac jucunde ') treatment of wounded on the battlefield, where a shortage of water for soaking the bandages might if necessary be met by using urine. The bandages were used in exactly the same way as Seutin's starch bandages, and the patient went about on crutches. Removal of the plaster was effected by wetting it and unwinding the constituent bandages. The technique was much advanced by its extensive use in the Crimean War both by the surgeons of the allied armies, and by the Russians.

In 1872 Samuel St. John[17] put forward very strongly the advantages of plaster. The splint, he writes, is fitted to the limb, and not the limb to a particular splint. It should be left undisturbed until union has occurred. Its disadvantage is that its application requires special skill if complications such as pressure sores and gangrene due to vascular obstruction are to be avoided. A great safeguard is to cut the wet plaster down the front with a shoemaker's knife. Between the skin and the plaster he placed a layer of cotton wadding or a single thickness of soft blanket. He tells that in the Franco-Prussian War the Germans used this method extensively,

employing tarlatan with plaster rubbed into its meshes, and wooden ribbons placed longitudinally between the layers of the splint to reinforce it.

In all this discussion of fracture treatment there has been little reference to the condition of the parts of the limb other than the fractured bone. Hippocrates used massage, but his successors so neglected the soft parts that stiffness was thought to be the inevitable result of immobilizing a fracture. Samuel Cooper,[18] one of the surgeons of his Majesty's Forces, wrote in 1818 :—

> All fractures, however simple and well treated they may be, are constantly followed by weakness and stiffness of the limb. These unpleasant consequences are the greater, the more violently the limb has been contused, the nearer the fracture is to a joint, and the longer the part has remained motionless, and without exercise. The stiffness always affects the inferior joint of the broken bone, much more than the superior. For the relief of these effects of fractures, it is customary to employ friction, liniments, emollient relaxing applications, cold washes and bathing; but sometimes, notwithstanding such remedies, the member does not quickly recover its strength, but continues stiff and weak for a year, or even a longer time. The most effectual plans for the prevention of this state should therefore be resorted to early. These consist in making the joints, nearest the fracture, execute slight motions, as soon as the union is sufficiently advanced, not to be in danger of interruption from this practice. A great deal of caution, however, is necessary in moving the part, and it is safer for the surgeon to superintend the business himself, than leave it to the patient or others. One of the best proceedings also for the hindrance of much weakness and stiffness in the limb after a fracture is to discontinue the splints and tight bandages immediately the state of the callus will allow.

Seutin's amovo-inamovible method was designed to allow local applications to the injured limb, of whose tendency to stiffness he was well aware. John Hilton's lectures,[19] first published in 1863, refer rather contemptuously to a masseur and dub him 'rubber'. Though they make little reference to fractures, there can be no doubt that the fervour with which they preached rest must have influenced fracture treatment.[20] Hilton describes the treatment of a complete dislocation of the knee by reduction of the deformity and fixation by a starch bandage.

Sir James Paget,[21] writing of "cases that bone-setters cure", says :—

> With rest too long maintained a joint becomes or remains stiff and weak and over-sensitive, even though there be no morbid process in it; and this mischief is increased if the joint have been too long bandaged, and still more if it have been treated with the cold douche. I need hardly say that it may be sometimes difficult to decide the time at which rest, after having been highly beneficial, may become injurious.

Lucas-Championnière[22] carried the idea of attention to the soft parts further. He considered a moderate degree of deformity a reasonable price to pay for absence of stiffness in a limb.

> Le retour du membre au maximum possible de puissance musculaire, au maximum possible de souplesse articulaire est cent fois plus intéressant que la forme exacte du squelette.

In 1879 he condemned the prolonged immobilization which was in such universal use; and he was consequently accused of having a phobia of ankylosis, being almost alone in holding these views. He also affirmed that callus-formation and union occur best when a regulated amount of movement is allowed, quoting experiments in which movements were allowed to animals whose limbs had been fractured. This hastened union and greatly increased the amount of callus, especially in young animals, where 'de véritables tumeurs osseuses' appeared. In children, owing to the activity of repair, movement should not be overdone, or excessive callus might cause inconvenience. In them massage is not needed, for

it exaggerates a process which is already perfectly sufficient. Immobilization, on the other hand, so interferes with the nutrition of bone that after two months there is a liability to spontaneous fracture. He quoted Ducroquet's observation that considerable force may safely be used in reducing a congenital dislocation of the hip-joint, but that, when the child has been months in plaster, a small clumsy movement may fracture the femur. If the limb is left free for a month, however, it regains its resistance to trauma. Lucas-Championnière found that surgeons had such belief in immobilization that they were reluctant to attribute this fragility to it, and preferred to postulate some disease of the bone.

Hugh Owen Thomas[23] (1834–91) contributed to medical knowledge the fact that immobilization of a healthy joint does not lead to ankylosis. To disprove Paget's view, stated above, he quoted a case.

> Two years ago I operated upon the feet of a lady suffering from contraction of the Achilles tendons, caused by the weight of the bed clothes during a long confinement to bed. The contraction had existed five years and totally prevented her locomotion, and she was consequently confined to a couch or bed during the whole of that period. Ten days after the operation she walked from my hospital, a distance of 800 yards, yet this joint had been fixed for a period of 5 years; there was not the slightest stiffness or adhesion in it. The stiffness was confined to the Achilles tendons only.

He also quoted a case described by Professor Flower :—

> A man whose skeleton is at Marburg was encased by his relatives for twenty years in a space in which he could only sit with his limbs doubled up, and in which he could have had only very narrowly restrained movements of his joints; yet his limbs did not become deformed, and his joints retained their normal textures.

Thomas applied his knee splint to fractures of the lower limb.[24, 25] For the first month or so after the accident, the limb was treated by fixed traction in a bed knee-splint. Then the lower ends of the side irons were bent in to fit into a socket cut through the heel of the patient's boot, thus making what we now know as a walking caliper. While the patient walked in this his fracture consolidated. Referring to delayed union he wrote :—

> Compressive fixation by the surgeon, having retained during treatment the part imperfectly supplied with blood . . . hindered the formation of a genuine repair. . . . In my opinion to apply an accurately fitted fixed dressing, such as for instance, a plaster-of-Paris bandage, is only to further delay the union and leave the restoration to chance.

However, as Thomas's hip splint gave way to plaster-of-Paris in the fixation of tuberculous hips, so has Thomas's knee-splint given way to walking plasters in the treatment of many fractures of the leg.

Krause[26] used a walking caliper for fractures of the femur, but in 1887 was apparently the first to use walking plasters for fractures of the leg. His method was as follows: Any deformity is reduced, and time then allowed for swelling to subside, compression and massage being employed if necessary. During this time the limb rests on a splint reaching above the knee, and fixing the ankle at right angles, or skin traction is used if there be any tendency to displacement. At the end of a week or so the skin is covered by two layers of muslin and an accurately moulded plaster cast applied, traction being maintained the while if there is any tendency to displacement. The knee is fixed in slight flexion, the ankle at right angles. The plaster extends from the heads of the metatarsals to mid-thigh. For malleolar fractures the plaster reaches only to just below the knee; for fractures

of the femur up to the tuber ischii. After the plaster has been applied, the patient remains in bed a further two days while it dries and then walks on the plaster unless the toes show much swelling. For walking in the street he is given a special laced boot that will fit over the plaster. During the early days of walking the toes become œdematous, but if use of the limb is continued this œdema (which spontaneously subsides during the night's rest) re-appears in smaller and smaller degree and finally disappears. Krause[27] writes of 98 fractures of the lower limb he had treated in walking plasters and found the time of healing much shortened by the method.

In 1894 Bardeleben[28] described his practice. He aimed at applying the plaster before any considerable swelling had arisen and said that in this way swelling was largely prevented. But if swelling should already have occurred this should not delay the application of plaster although a fresh plaster would be required when subsidence of swelling caused loosening. The plaster must also be changed if it is causing any localized pressure.

Korsch[29] applied plaster directly to the naked skin, which is thus better fitted and gripped. The skin was, however, previously greased to prevent actual adherence of plaster. He also used a metal stirrup for transmitting the patient's weight to the ground.[30] This was a U-shaped piece of iron, put to the ground in walking, whose side limbs were incorporated in the plaster and so indirectly gripped the tibial condyles. For fractures of the femur he incorporated part of the ring of a Thomas's knee-splint in the top of the plaster to give counter-traction against the ischial tuberosity. Another of Bardeleben's assistants, Albers,[31] made plaster do the work of this ring. He points out that when a walking plaster is removed the patient is able at once to walk without it. Any stiffness of the joints disappears in a few days.

In 1903 Guitard[32, 33] wrote on the ambulatory treatment of fractures of the lower limb, describing in particular the apparatus of M. Robert Sorel, his chief at L'Hôpital Pasteur du Havre. He refers to the stiffness that had come to be thought inseparable from treatment in plaster and attributes it to muscular atrophy, shortening of ligaments and capsule, and diminution of the area of articular cartilage. Traumatic effusions in ligaments, muscles, and cellular tissue may lead to fibrosis if the limb is kept motionless. Massage can get rid of these effusions and diminish pain, swelling, and wasting. But in the lower limb an even better method is available. By walking in his plaster the patient is spared the inconvenience of having to stay in bed—boredom, discomfort, general muscular weakness, loss of appetite, bronchopneumonia, expense—while bony union occurs more quickly than by any other method except massage and movement, which takes about the same time. Within the apparatus muscles contract, stiffness is prevented, and a good circulation maintained.

Many objections to the method had been raised. That there was not sufficient immobilization of the fragments, so that deformity would recur. That it was impossible to get a proper bearing for taking the patient's weight. That if padding separated the plaster from the skin it would become displaced and lumpy, whereas if there were no padding there would be pressure sores. Guitard observed that in practice deformity does not recur, while a slight degree of movement (as had been shown by Lucas-Championnière) helps union. The method is applicable to fractures and osteotomies of the leg or thigh, and to excision of the knee. The apparatus is applied as follows: Any deformity is reduced while traction and counter-traction

are exerted by the hands of assistants. A plaster-of-Paris bandage is then wound direct on to the skin, being well moulded to prominences and depressions and being thus enabled to fix the traction. A metal U similar to that of Korsch is then held in the axis of the limb so as to project 4 cm. below the heel, and is attached over the plaster by further plaster bandages. The patient can walk on the lower end of the U from the day following the application of the apparatus. For fractures near the ankle with displacement, the plaster must include the ankle-joint. For those at a higher level it stops below the malleoli. Above it finishes for fractured leg at the tibial tuberosities, for fractured thigh at the tuber ischii, these points bearing the patient's weight in walking. Fixation of joints is avoided when possible, as frequent movement of them was thought important to prevent stiffness. A photograph shows the foot bandaged to " avoid the œdema that is seen during the first days following the application " of the apparatus.

Korsch and Guitard did not immobilize the ankle-joint unless they thought this essential to the maintenance of the corrected position of the fracture in question. Delbet[34] introduced a skeleton below-knee plaster, consisting of a strip down each side joined by a band around the malleoli and a second band round the tibial tuberosities. The sole of the patient's foot was actually in contact with the ground as he stood, for the side strips stopped below the malleoli just short of the ground. Delbet claimed that weight would be transmitted from the upper part of the leg through the apparatus to the lower, but in practice the plaster merely splinted the malleoli from lateral displacement, and his photographs show that almost all his patients used crutches. For severe fractures such as Pott's fracture-dislocation the apparatus proved inadequate and window-œdema appeared between the strips, while for less severe fractures it was unnecessary. The fact that immobilizing an ankle-joint does not make it stiff invalidates the one possible object of the Delbet plaster.

During the war of 1914–18 Lorenz Böhler[35] adopted on a large scale plaster-of-Paris for treating the war fractures that came under his care in Austria. He had one great advantage over the previous advocates of plaster. Radiography had been introduced and perfected since the days of Krause, Bardeleben, and Sorel. That his methods closely resemble theirs can be appreciated by comparing their writings with his book and with the work to be seen in the Unfallkrankenhaus at Vienna.[36, 37] Great stress is laid on 'functional treatment', the patient using to an extent that must be seen to be believed the fractured part enclosed in plaster. Such natural use of muscles renders superfluous that poor substitute, massage.

Ability to walk within such a short time of sustaining a fracture is accounted for by the fact that the plaster transfers the patient's weight from some point above the fracture to the ground. In considering what this point is it is useful to remember how an artificial limb bears the patient's weight. The principle of tuber-bearing we owe to a mechanician named Bigg,[38] who wrote in 1855 :—

> If after amputation above knee a stump thinly covered by integument remained, and a mere bucket or hollow wooden sheath were adjusted, regardless of anything but conformity to external shape, the effect would be to draw the flesh upwards and produce, not only painful, but injurious pressure on the end of the stump. Whereas, were that portion of the stump called the tuberosity of the ischium selected for the principal point of resistance, and the remaining part of the bucket left free, the patient would with ease rest the whole weight of his body upon the false leg without in the slightest degree uplifting the fleshy part of the stump.

The plaster applied for fractures of the upper end of the tibia encloses the whole thigh, so that the patient really sits on the top of it. This seat resembles the cup of a Hessing splint more than the ring of a Thomas's caliper. Pressure is also transmitted to the tibial tuberosities and tubercle, to the head of the fibula, and to the patella. These take all the weight in fractures of the lower end of the tibia, when the plaster is not carried up as far as the tuber ischii. The plaster even fixes traction by taking a grip of these points above and of the malleoli and foot below. The bony points are covered by aponeurosis, fascia, and little fat, and therefore the grip does not become loosened. The plaster is not removed until union is firm. After its removal swelling of the limb is prevented by bandaging. Joints show little stiffness, and this is soon remedied by use. As walking in plaster will induce a case of delayed union to unite, so does it assist the union of recent fractures. The impression of the accident on the patient's mind is minimized when he is able to walk about and live at home.

Since the publication in 1929 of Böhler's book describing his methods, the use of functional plasters has been widely adopted. It is found that a fracture causes least harm and inconvenience when during healing a plaster exo-skeleton does vicarious duty for a damaged endo-skeleton.

SUMMARY

In this history three phases in the use of plaster may be recognized. In the first all attention was concentrated on the bone, as is shown in the writings of Cheselden and Larrey. In the second, following Seutin and Lucas-Championnière, prior consideration was given to the soft parts. Krause and Böhler are outstanding names in the third phase, wherein fixation is so efficient that the limb may be used and kept supple without endangering the position of the bony fragments.

For more than 4000 years before Seutin there was little variation in the method of use of the starch or gum splintage. Occasionally someone would substitute plaster for gum, but the resulting splint was better than a strip of wood still only in its better fit. The apparatus was immovable and remained on the limb until union of the fracture was expected to be firm. It was generally extremely clumsy —for example, Larrey's conglomeration of bandages, leather, straw, string, and cushions of chaff, the whole saturated with white of egg and other substances. When the apparatus was removed the limb was found to be wasted and stiff. The principles of traction and counter-traction, however, were well understood.

Seutin first pointed out that rest in bed, though an excellent basis for the treatment of most illnesses, is actually harmful to patients recovering from fractures. The light, portable, starch apparatus that he introduced enabled his patients to make use of this knowledge, and, if the lower limb were fractured, they went about on crutches. Seutin's interest in the soft parts of the limb was shown by the way in which he split his apparatus to see that a satisfactory fit was maintained, and to make applications to the limb. These came to take the form of massage, later emphasized by Lucas-Championnière, and to this day massage of a limb that is supported by split plasters forms one method of treatment. To prevent stiffness, joints were moved as much as possible.

Mathysen's plaster bandages made the application of plaster-of-Paris comparatively simple, and for orthopædic purposes permanently replaced starch and

other hardening dressings. Thomas first made the patients walk in apparatus, thus bearing weight on the tuber ischii instead of on the axilla. They were enabled to continue exercising the limb while the bone united. Krause put plaster to the same purpose, while to Böhler is due the recent perfection of this technique.

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HÆMORRHAGE PER RECTUM AS AN INDICATION OF DISEASE IN A MECKEL'S DIVERTICULUM

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THIS paper owes its inception to the fact that during the past three years there have been four cases of severe hæmorrhage per rectum owing to disease of Meckel's diverticulum in the surgical practice of the Sheffield Royal Hospital, and also it appears to be a condition of sufficient rarity and importance to warrant record.

The existence of the diverticulum was first noticed by Ruysch in 1701, but it was not until 1812 that the Tyrolese anatomist by whose name it is known pointed out its true embryological significance.

DISEASES OF THE DIVERTICULUM

The following general facts are of interest before considering one of its diseases in detail. In the 2 per cent of bodies containing Meckel's diverticulum, some 82½ per cent of the diverticula are free-lying, 10 per cent have a free or attached band at the apex, 6 per cent show fistula, and the remaining 1½ per cent show some other abnormality. In pathological conditions about five times as many males are affected as females, and this is greater than the proportional difference of the occurrence of the abnormality in the two sexes. Also at least 30 per cent of the lesions occur under the age of three years, and they are associated with other congenital abnormalities more often than any other form of 'acute abdomen' in childhood.

Owing to its origin, situation, and the aberrant mucosa it often contains, this diverticulum is subject to even more diseases than have brought an unenviable reputation to its near neighbour, the vermiform appendix. These may be classified as: (1) Inflammation—with or without ulceration; (2) Obstruction—of itself or of the bowel by bands, intussusception, etc.; (3) Fistula—congenital or acquired; (4) Neoplasms—of which lipoma, myoma, myxoma, angioma, adenoma, carcinoma, sarcoma, and carcinoid tumours have been reported; (5) Associated local abnormalities—mesenteric cyst, enterocystoma, and duplex ileum.

The literature on the subject is endless with the exception of this condition of bleeding per rectum, which has received but scant notice save in Germany and the United States. The first cases showing this type of hæmorrhage were reported in 1896 but were all due to intussusception of the diverticulum, and it was not until 1903 that Hilgenreimer placed on record a case of bleeding due to ulceration. Between 1903 and 1922 6 more cases were reported, but since then some 70 have been recorded, mostly from Germany and the United States. It is from a study of the Sheffield cases and of the available literature that the following facts have been gleaned.

ETIOLOGY OF THE HÆMORRHAGE

1. **Ulceration.**—The first cases to be recorded showed ulceration of the peptic type so frequently found in the stomach and the duodenum, and this resulted in a search for any factors in common. By serial section of thirty Meckel's diverticula Schaetz showed that 16 per cent contained aberrant gastric mucosa, and a further 5 per cent showed both aberrant gastric and pancreatic mucosa. This led to the supposition that the oxyntic cells of the aberrant mucosa secreted acid and so were the predisposing cause of the ulceration. The ulceration was found to occur in the aberrant mucosa, at its junction with the normal mucosa, and in the normal mucosa ; in fact, the majority seem to be situated in the latter position near the base of the diverticulum.

Operative and post-mortem records show that typhoid ulceration occurs in the diverticulum in association with the typical lesions in other parts of the bowel. Also tuberculous ulceration has been recorded, but as there was similar ulceration in the ascending colon, the hæmorrhage from the rectum could not be attributed to the condition of the diverticulum.

2. **Mechanical Theory.**—Quite apart from those operated upon for intussusception it was found that a certain number of cases showed ulceration when no aberrant mucosa was present. These were explained by Winkelbauer as being of traumatic origin. Irregular peristalsis produced either invagination of the apex or incipient intussusception of the base of the diverticulum into the small bowel, so causing either apical or basal ulceration.

3. **Recurrent Inflammation.**—A very few cases have been recorded of undoubted hæmorrhage from diverticula which showed no signs of either aberrant mucosa or of ulceration. All of these could not be accounted for by a mechanical theory, as the tip of the diverticulum was in some cases adherent to the mesentery or other loops of bowel, so preventing incipient intussusception or invagination with its resulting congestion and hæmorrhage. These, I think, must be due to recurrent inflammation of a hæmorrhagic nature or possibly to acute microscopic ulcers such as are alleged to occur in gastrostaxis.

4. **Infarction.**—Hunter records a case of melæna neonatorum which at autopsy proved to be due to infarction of the diverticulum, though I have been unable to find any other such case.

5. **Neoplasm.**—Finally, cases due to new growth of the diverticulum with the presenting sign of hæmorrhage per rectum have been recorded. Of the 9 I have been able to find, 7 were due to carcinoma or sarcoma, 1 to myoma, and 1 to adenoma of aberrant gastric mucosa.

DIAGNOSIS

In general it may be stated that 85 per cent of the cases are male, though two of the four new cases reported here are female ; that the age incidence varies from a few days to the sixth decade ; but that the average age at operation is a month or two over ten years.

The following, in their order of frequency, may be associated with the hæmorrhage from the rectum—anæmia, pain, vomiting, and bowel irregularity. The diagnosis is made by a process of exclusion, though hæmorrhage per rectum in a juvenile between the ages of 5 and 15, especially if a boy, is very suggestive.

The hæmorrhage is usually sudden and severe, though in cases of growth it may be slight and continuous. The blood is dark in colour, unless associated with diarrhœa, when it may be bright red, is thoroughly mixed with the stools, and unaccompanied by mucus. One case recorded by Stone showed umbilical hæmorrhage via a patent vitello-intestinal duct as well as melæna from an ulcer at the base of a diverticulum.

Pain occurs in about half the cases, is of colic type and never severe and prolonged unless associated with intestinal obstruction, and is situated in the umbilical region. The attacks of pain do not appear to have any definite relationship to food, as is so frequently found in peptic ulceration ; and no aggravating or relieving factors are mentioned in the case reports. In McKeen's case, a man aged 53, it preceded hæmorrhage by twenty years and only became severe at the onset of the bleeding which led to his admission to hospital.

In about a quarter of the cases nausea and vomiting occurred quite apart from any marked pain or obstruction. This is probably due to sudden local distension of a segment of the bowel giving rise to reflex sickness or as a reaction to sudden acute anæmia.

Bowel irregularity is rare, and was either diarrhœa following sudden severe bleeding into the lumen of the bowel, or rapidly increasing constipation which in every case necessitated urgent operation for acute intestinal obstruction.

If the blood loss has been acute, then the patient shows a typical hypochromatic anæmia but with increase of platelet count and of coagulation time, but when the loss is chronic, a colour index of 0·5 or lower is found.

In clinical examination the only positive finding is blood in the stools either as melæna or occult blood. Physical examination of the abdomen, sigmoidoscopy, and radiological examination, whether by barium meal or enema, are invariably negative.

In the child lesions of the alimentary tract such as gastro-enteritis, acute intussusception, and local ano-rectal conditions are easily excluded. Also the general diseases such as purpura, leukæmia, etc., should present no difficulty. In fact between the ages of 5 and 15 melæna is a very rare condition and should at once suggest the possibility of disease of Meckel's diverticulum.

In the adult the cause of the passage of bright red blood can usually be discovered by sigmoidoscopy and barium enema, though a single polypus or a localized area of hæmorrhagic colitis may cause difficulty when situated in the pelvic colon. But it should be noticed that these two conditions when associated with diarrhœa also show mucus in the stools, while red blood is always associated with diarrhœa and no mucus in diseases of the diverticulum. If there is left-sided enlargement of the heart, the blood-pressure should be taken, as hyperpietic patients occasionally suffer from bleeding due to rupture of a rectal blood-vessel. As the majority of cases show melæna rather than bright red blood, cirrhosis of the liver, peptic ulcer, and the less frequent cause, gastric carcinoma, must be excluded. The former is distinguished by hæmatemesis, ascites, splenic enlargement, and sometimes dilated veins on the abdominal wall, and the other two by history and X-rays. Of the rarer conditions causing melæna, primary peptic ulceration of the jejunum deserves notice. The very few cases recorded tend to show pain with a definite time relationship to food, periodicity, and attacks of melæna simulating a duodenal ulcer except that the pain is situated lower down and to the left of the umbilicus. In every case

X-rays showed obstruction, as the ulcer tends to encircle the bowel. However, as with peptic ulcer of Meckel's diverticulum, nearly all the cases were first seen after perforation or obstruction had taken place. Primary carcinoma of the small bowel gives rise to vague pain and attacks of colic in the left iliac fossa, sooner or later passing on to obstruction, melæna not being a presenting sign. One or two cases are reported of bleeding from diverticula other than Meckel's, and it is just possible that the diagnosis might be made by X-rays though impossible clinically. General diseases as a cause can be excluded by routine examination, blood tests, etc.

TREATMENT AND PROGNOSIS

Treatment.—The treatment of the condition is surgical, and operation should be undertaken as soon as possible after diagnosis. Mason records five cases in which medical treatment was tried, after making the diagnosis of peptic ulcer of the diverticulum, and all ended fatally, surgery being invoked only after complications had arisen.

If the hæmoglobin is below 30 per cent, operation should be preceded by blood transfusion, which must be repeated rather than resort be made to the iron-deficient diet and prolonged rest usually prescribed by physicians for such conditions.

At operation resection of the diverticulum is all that is required.

Prognosis.—Greenwood states that for the ulcer group the mortality is 58 per cent of the perforated cases and 8 per cent of the non-perforated cases, and, as far as I can ascertain, the latter figure is accurate for all cases not showing perforation or obstruction at the time of operation.

CASE REPORTS

Case 1.—Male, aged 22, under the care of Professor Graham Simpson.

When aged 8 he suffered from lassitude for several weeks; this was followed by a sudden collapse on Boxing Day, 1921, when he passed a large quantity of bright blood per rectum. For some days after the stools were dark in colour, but there was no pain. He was seen by a consulting physician, but no diagnosis was made. He resumed normal life the following Whitsuntide, and there were no more symptoms until 1930, when he began to have attacks of discomfort in the abdomen and mild attacks of colic. He also had attacks of breathlessness and pain in the area supplied by the 3rd and 4th cervical nerves on the left side. The pain had no relation to food and there were no aggravating or relieving factors noticed. He was "off colour" the whole time until July 31, 1932, when without warning he was taken with severe hæmorrhage per rectum, the blood being of dark colour, unmixed with mucus, and the stools remaining discoloured for ten days.

On Aug. 3 he was admitted to hospital. Physical examination was negative, but there was much blood in the stools. Blood examination showed: Red blood-corpuscles 2,900,000, platelets 290,000, differential count normal, bleeding and coagulation times normal. The bleeding ceased after a blood transfusion given on Aug. 7. Plain X-ray of the chest and abdomen, barium meal, and barium enema were all negative.

On Sept. 8 he was discharged with the diagnosis of acute duodenal ulcer, and placed on medical treatment, which he has followed ever since.

On Jan. 11, 1933, he was re-admitted for hæmorrhage per rectum; this as in the last attack was unassociated with pain, and again complete radiological examination of the alimentary tract proved negative. He was discharged on Feb. 8, as both the patient and the consulting physician were against exploration. From February to the following Easter he suffered vague abdominal pain and was admitted again on April 5 with further hæmorrhage.

On April 10 Mr. J. C. Anderson operated for Professor Graham Simpson and found a large mass of tuberculous glands and adherent bowel in the ileocæcal angle; the loop was

resected, the two ends of the ileum were closed, and side-to-side anastomosis between the ileum and the cæcum was performed. On examination of the adherent bowel a Meckel's diverticulum was found containing a peptic ulcer $\frac{1}{3}$ in. in diameter. There has been no bleeding since, though he has suffered from vague indigestion for the past eight months. In December, 1934, physical examination and radiology showed no abnormality.

Case 2.—Female, aged 11, under the care of Mr. H. Blacow Yates.

This girl was staying in Derbyshire for the Easter week-end. On April 16, 1932, she was taken with sudden colic pain in the umbilical region followed by vomiting of food. This was immediately followed by the passage of a considerable quantity of blood, which covered her knickers and which her mother thought was her first menstrual period. The blood was said to be " fairly bright " but mixed with dark clots, and there was no slime on the knickers. The child went very faint, but this was attributed to the shock of seeing the blood; but two hours later a call to stool resulted in the further passage of blood. The motion next morning contained dark blood and she complained of feeling faint. That day (April 17) she was seen in consultation by Mr. H. Blacow Yates. Abdominal examination was negative except for slight tenderness just below the umbilicus. The rectum was entirely negative apart from containing dark blood. A tentative diagnosis of bleeding from a peptic ulcer of a Meckel's diverticulum was made and the child admitted to hospital. Previously the child had enjoyed good health and there had been no attacks of abdominal pain or dyspepsia.

Radiography of the alimentary tract was negative, as was sigmoidoscopy. Examination of the stools was negative, and the tourniquet test and platelet count seemed to rule out purpura.

On April 23 operation was performed after the case had been demonstrated as a case of bleeding ulcer from a Meckel's diverticulum to a post-graduate clinic. The terminal ileum was seen to contain dark bloody fluid, and a foot from the ileocæcal valve an indurated inflamed lump was found. This was seen to be a swollen congested Meckel's diverticulum adherent to the ileum above and to the adjacent mesentery. The diverticulum was easily separated from the gut and the mesentery. The distal half of the diverticulum was found

FIG. 193.—*Case* 2. External appearance of the diverticulum, showing the perforation of the viscus after separation from the mesentery.

FIG. 194.—*Case* 2. Internal appearance of the diverticulum, showing typical acute peptic ulceration.

to be acutely inflamed, œdematous, and indurated, whilst the peritoneal covering was acutely red. There was a minute perforation of the entire wall of the diverticulum after separation had been completed. The diverticulum arose from the antimesenteric border, was about 2 in. in length, and about $\frac{3}{4}$ in. in diameter at its junction with the ileum. It was resected with the endothermy needle and the opening sutured. The raw surface which had formed its bed on the upper surface of the mesentery was swabbed with spirit and peritonealized. There was no blood in the bowel above the origin of the diverticulum. The accompanying drawings illustrate the condition excellently (*Figs.* 193, 194). Section showed typical aberrant gastric mucosa around an acute peptic ulcer. No oxyntic cells could be demonstrated in the aberrant mucosa, however.

The child was discharged to the Convalescent Home on April 29, and in reply to a letter on May 1, 1935, her parents stated that she was in perfect health.

Case 3.—Female, aged 6, under the care of Professor G. Simpson.

On July 19, 1933, she was admitted with the following history: She had been admitted exactly a year before after a sudden hæmorrhage per rectum of bright red blood for about three days, followed by dark blood for about a week. Marked anæmia was present, but no other sign or symptom. Physical examination, including sigmoidoscopy, was negative and she was discharged. A year later a small hæmorrhage took place of dark blood and she was at once re-admitted. Physical examination and radiography were negative and a laparotomy was performed on July 27 with the pre-operative diagnosis of ? polyp ? ulcer of Meckel's diverticulum. Thirty-two inches from the cæcum a Meckel's diverticulum was found adherent to the right ovary. The diameter at the base was that of the small bowel, and it was about 2 in. long. It was resected.

She was discharged on Aug. 8, 1933, and it was stated that she had never had any trouble since, when seen in May, 1935.

PATHOLOGICAL REPORT.—Gastric mucosa present with peptic ulcer.

Case 4.—Male, aged 16, under the care of Mr. J. B. Ferguson Wilson.

The patient was admitted on Feb. 2, 1935, with the following history: In the later part of August, 1934, he was taken with slight colicky pain in the umbilical region lasting an hour or two, usually half an hour after food; this lasted a week. In October, 1934, he was pushing his bicycle up a hill when he was taken with diarrhœa and nausea. There was no pain and the stools contained dark blood without mucus and ceased in a few hours'

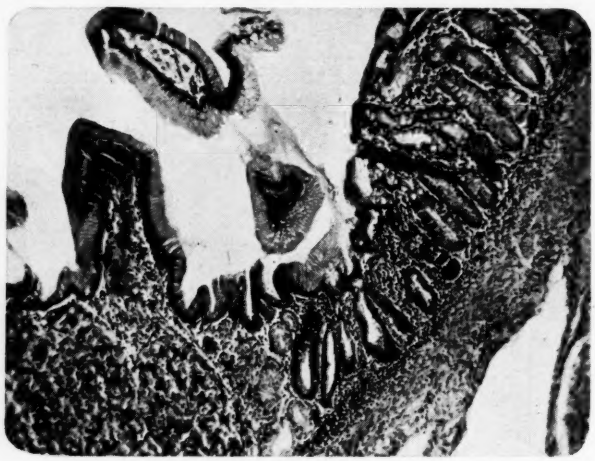

FIG. 195.—*Case* 4. Microphotograph showing aberrant gastric mucosa in a Meckel's diverticulum. (× 50.)

time. He went back to school in a fortnight's time, but suffered from spasms of colic in December and January, these nearly always occurring about an hour after breakfast, though occasionally at other times of the day. On Jan. 29 he was taken with severe colic for about ten minutes in the afternoon, and the next morning noticed bright red blood in the motions. On the evening of Jan. 30 he fainted while going to the W.C., was sick, and passed several very bloody stools. The next day he was seen by Mr. Ferguson Wilson, who diagnosed peptic ulcer of a Meckel's diverticulum and had him sent into hospital. Physical and blood examinations were negative.

On Feb. 9 he was operated upon, and a Meckel's diverticulum was found with the small intestine below it filled with blood but none above it. It was resected. On Feb. 23 he was discharged, and has had no further trouble since.

PATHOLOGICAL REPORT.—Sections show an acute peptic ulcer in the gastric mucosa of a Meckel's diverticulum (*Fig.* 195).

SUMMARY

1. Four cases of hæmorrhage per rectum due to peptic ulcer of Meckel's diverticulum are reported for the first time.

2. From the available literature the etiology of all forms of bleeding due to disease of this diverticulum is given together with the differential diagnosis.

3. Finally, laparotomy for the removal of an ulcer containing diverticulum is urged in children between the ages of 5 and 15 years showing hæmorrhage per rectum the cause of which is not revealed by sigmoidoscopy and blood examination.

I wish to express my thanks to Professor Graham Simpson, Mr. J. B. Ferguson Wilson, and Mr. H. Blacow Yates for allowing me to record their cases, and especially to the latter for the loan of the drawings of his case and help in writing this paper.

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INTUSSUSCEPTION OF JEJUNUM INTO STOMACH THROUGH A GASTRO-ENTEROSTOMY STOMA

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AND W. DOUGLAS MACFARLANE

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R. D., aged 52, dock labourer, was admitted to the Victoria Infirmary, Glasgow, first of all in April, 1928, when a posterior gastro-enterostomy was performed with invagination of a duodenal ulcer. He continued in good health, though suffering periodically from gastric discomfort, until January, 1934, when he complained of pain after meals, never of sufficient severity to make him stop work, and he was relieved in a short time by appropriate medical treatment.

FIG. 196.—Post-mortem appearance of intussusception of jejunum into stomach.

On July 9, 1934, he entered hospital free from any gastric symptoms, in order to have an inguinal hernia removed, and this was done on the following day under local anæsthesia. He was apparently quite comfortable until four days afterwards, when he complained of nausea and vomited some gastric contents. There was no pain. Vomiting then became bilious in character, later rather brown in appearance, and on the morning after he vomited 2 oz. of blood. Pain was now slight, but there was no rigidity or tenderness in any part of the abdomen except over his recent operation wound. No distension was evident, liver dullness was normal, and peristaltic sounds were heard on auscultation throughout the abdominal area. Later in the morning he again vomited small quantities of bright red blood and

seemed thereafter somewhat better; he was not distressed or restless, the pulse was 84 and of good volume. In the afternoon he became drowsy and soon began to sink rapidly; he died in the early evening just twenty-four hours from the onset of his first symptoms.

POST-MORTEM EXAMINATION.—A well-made, well-developed man; nothing of importance or relevance was found in the head or thorax; the operation wound was healing normally. On opening the enlarged and distended stomach, it was seen that a mass of congested and semi-gangrenous jejunum occupied the greater part of the cavity and was surrounded by dark effused blood (*Fig.* 196). On removing the organ, one was impressed by its most unusual weight.

Measurements.—The lesser curvature was 9 in. in length, the greater curvature 18 in., and the distance between these limits and over the anterior surface of the stomach was approximately 7 in. The intussusception measured 10½ in. in length and the diameter of the stoma was about 1½ in. Its condition was such that no reduction was possible without tearing the gut.

Histological Examination.—Sections of mucous membrane from areas around the stoma and from the jejunum were prepared. Intense venous congestion was apparent and a great deal of intercellular effusion, but putrefactive changes were so advanced that nothing further could be established. Even so, it was clear that during the twenty-four hours that the process had presumably taken, a very large quantity of fluid had exuded into the intussuscepted area.

COMMENTARY

Six years had elapsed from the original operation until death took place, an interval, curiously enough, which seems to be the recorded average. With the exception of Lewisohn's case (which occurred on the sixth post-operative day) a few months and five and a half years are the limits of time in which this complication has been observed after gastro-enterostomy, and the type of operation performed does not seem to affect the issue at all. Baumann reports one case of recurrence eight weeks after the initial reduction. This was relieved by resecting 10 cm. of intussuscepted jejunum.

The symptoms vary considerably in different patients. Pain is sometimes described as severe and cramping, again as just " tightness in the epigastrium ". In our case pain was never severe and for a long time was absent. Vomiting, first of gastric contents, then of bile, ultimately of blood in greater or less quantity, has always been described, and there is agreement in the rapidity with which patients go downhill.

Rigidity and distension are frequently marked, and in about 50 per cent there is a tumour-like appearance of the upper abdomen. The pulse is usually good until shock supervenes, and according to Shearer and Pickford this applies also to blood-pressure. They further state that there is no leucocytosis or rise of temperature.

Our report brings the total of published cases to 37, nearly all of which were first seen as surgical crises. But it is more than probable that an intussusception of this type is not so uncommon as that small number would suggest, and that a chronic or intermittent form may, in fact, follow many operations for gastro-enterostomy. Sibley has described an example of this kind. The patient complained of no pain or nausea or vomiting, but there was a feeling of constriction in the mid-epigastrium and inability to endure anything tight about the waist. The attack lasted for one to three hours after meals, and on fluoroscopic

examination it was found that a loop of jejunum had entered the stomach through a gastro-enterostomy stoma. At operation, though a large opening was present, no intussusception was found at that instant. The intussusception was present only after meals and presumably was effected during peristalsis, the large stoma accounting for the ease with which self-reduction was effected.

More than ten years ago Drummond suggested in this JOURNAL that the presence of the stoma may make possible a more rapid emptying of the stomach, with consequent irritation of the jejunal mucous membrane, sufficient at times to initiate antiperistalsis and lead to jejunal intussusception. More recent radiological knowledge has tended to confirm this view, and the demonstration of ' inflammatory cushions ' round the stoma with concurrent jejunitis (Berg) has enabled us to visualize the mechanism by which antiperistalsis might be initiated.

In conclusion we would urge that the high mortality rate from this complication justifies us in drawing attention to it once more, and we feel, too, that only by systematic radiological examination after gastro-enterostomy can the incidence of the chronic form be revealed, a condition which might easily account for the otherwise inexplicable symptoms which sometimes follow gastro-enterostomy.

SUMMARY

1. An acute intussusception of jejunum into stomach through a gastro-enterostomy stoma is described as found at post-mortem examination.

2. A summary of the etiology and symptomatology of the recorded cases is given and the bibliography is brought up to date.

3. It is suggested that a chronic or intermittent form of intussusception, one example of which is epitomized, may be more common than is generally believed.

Our thanks are due to Dr. Goudie, Saltcoats, Ayrshire, for his information about this patient's condition while under his care, and to Mr. J. M. McCorquodale, Senior Laboratory Assistant, Victoria Infirmary, Glasgow, for the photograph.

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A FURTHER NOTE ON THE DEVELOPMENT OF CYSTS IN CONNECTION WITH THE SEMILUNAR CARTILAGES OF THE KNEE-JOINT

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In 1921 I reported in the British Journal of Surgery[1] the first 3 cases of this condition to be recorded in English or American literature. In 1929, also in this journal,[2] I reported a further 18 cases and reviewed a number of reports by English and American surgeons, some of whom had dealt with as many as 11 cases. It was obvious that the condition was becoming well recognized. Since my last paper I have operated upon a further 20 cases, making 41 in all. In one patient the condition was bilateral, so that 42 knees were dealt with. As I said in my report of 1921, and as every observer has since agreed, the whole cartilage, with the cysts, must be removed to prevent recurrence. It is not clear from the published reports exactly how some of these writers have verified my statement that the whole cartilage must be removed; so far as I know, no clinical evidence has been produced by them. In my first paper I gave the history of one case in which the cyst only had been removed and which had developed a new and definite intra-cartilaginous cyst, causing symptoms, eighteen months later. It was on this case, and on the previously reported local excisions, with recurrence, of Ebner,[5] Riedel,[6] and Haehnel,[7] that I made the statement as to the total excision of the cartilage. I have had no opportunity since that time of further proof because in every case I have removed the whole cartilage. The fact that total removal of the cartilage is required is perhaps a point which helps to throw some light on the rather disputed etiology of the cysts.

If, as some are inclined to think, the cyst is purely degenerative and consequent upon a trauma to an area of cartilage, it would seem that the simple removal of the cystic portion should be sufficient to effect a cure and that, apart from further trauma, there should be no further development of cysts. But this is not the case; all who have reported personal experience of local removal are agreed that fresh cysts are formed without any evidence of further trauma and that complete excision of the cartilage is essential. One other point should be mentioned in connection with the traumatic degeneration theory. King[8] says that the usual history of trauma supports the view that the cysts are an acquired condition following upon injury and subsequent degeneration. Everyone will agree that the semilunar cartilage which is most commonly damaged is the internal, and it would therefore be natural to expect to find such degeneration cysts much more frequently in the internal than in the external cartilage. The opposite is the case; in the series which I now record, and which is the longest series so far published, the figures show only 6 internal cartilage cysts against 36 in the external cartilage. It is true that the cysts are generally found in the thicker, peripheral, portion of the cartilage, which is the

area most exposed to trauma, but in the new cases which I am now reporting I have found one case in which the cyst arose from the free border of the external cartilage and projected towards the middle of the joint, lying against the crucial ligaments.

This specimen is depicted in *Fig.* 197. It is the only case which I have encountered, or of which I have heard, in which the cyst projected to the centre of the joint and not towards the skin. It was removed from the joint of a girl aged 11 years who, at the age of 6, sprained the knee. Recovery appeared to follow, but after a few months (history is not quite definite on this point) the knee would 'go stiff' and the patient would limp. After a little exercise the stiffness and the swelling which always occurred would pass off. Limited extension of the joint had happened on several occasions. An exploratory arthrotomy was decided upon.

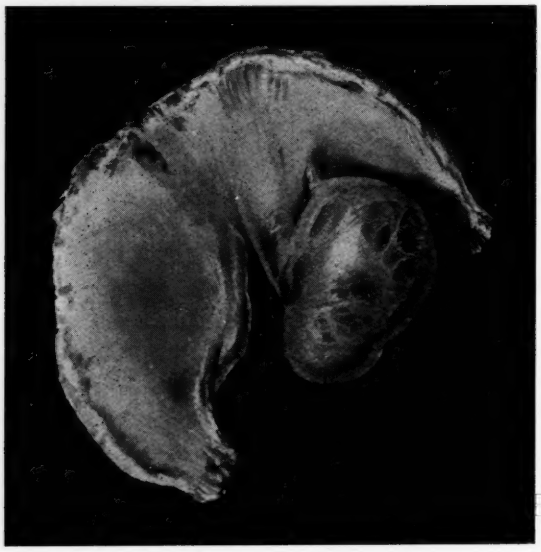

FIG. 197.—Cyst of the semilunar cartilage of the knee-joint.

OPERATION (Nov. 23, 1931).—General anæsthesia. The skin was incised along the long axis of the limb and the patella split longitudinally. On retraction a cystic swelling, the size of a cherry, was found to be attached to the free (medial) edge of the outer semilunar cartilage and lying closely against the crucial ligaments. The cartilage was an unusually broad one. It was excised completely with the cyst. In freeing the anterior attachment the cyst, which was very thin-walled in that region, was accidentally burst and the usual gelatinous contents escaped. The patella was approximated and the tendon sutured with catgut; no sutures were passed through the bone. The recovery was uninterrupted and the girl has had a normal joint in appearance and in function since that time.

There has been a considerable amount of discussion as to the nature of the cysts and their microscopical structure. All the sections of my specimens have been made by the same pathologist (Dr. C. E. Jenkins) and every cartilage removed has been examined by sections. We believe that an endothelial lining to the cysts can be demonstrated, and in my 1929 paper sections were shown which appeared to us to establish that point. Kleinberg,[3] reporting one case, found a flat layer of

endothelial cells lining the cyst, and suggested that these cells arose from lymph vessels. Zadek and Jaffe[4] refer to sections of their specimens removed at the New York Hospital for Joint Diseases, and find a definite layer of endothelium particularly lining the smaller spaces. Others have not been able to identify this layer. I have therefore asked Dr. Jenkins to append his views to the present report.

ANALYSIS OF PRESENT SERIES OF 20 ADDITIONAL CASES (21 KNEES)

Males	16
Females	4
Ages	From 11 to 58 years
External cartilage affected	19
Internal cartilage affected	2
Right knee affected	11
Left knee affected	10
Bilateral	1

ANALYSIS OF WHOLE SERIES OF 41 CASES (42 KNEES)

Males	33
Females	8
Ages	From 6 to 58 years
External cartilage affected	36
Internal cartilage affected	6
Right knee affected	20
Left knee affected	22
Bilateral	1

THE NATURE AND RECOGNITION OF ENDOTHELIUM: WITH SPECIAL REGARD TO THE SILVER METHODS OF STAINING

BY C. E. JENKINS

We define 'endothelium' as any specialized layer of cells derived from the mesoderm and lining a cavity. In our view the term should not be restricted to the types of cells found in the circulatory system, but should include synovial cells also. It may well be that the cells lining the cartilage cysts have affinities with synovial cells; on that point we offer no definite opinion. King[8] suggests that by the use of silver staining we may decide definitely that the lining cells are not vascular endothelium. The value of silver impregnation as a differential stain can be exaggerated. Silver stains intercellular material; consequently, tissue rich in this substance takes the impregnation extensively and in proportion to the intercellular material which is present. A cross-section of a blood-vessel so stained does not show the endothelial layer because the cement substance is in a plane too small to be visible. But to assert that vascular endothelium does not stain with silver is incorrect. The metal can, in fact, be used to demonstrate the differences in the endothelium of arteries, veins, and lymphatics.

No reliance can be placed upon silver as a means of demonstrating cells. The two photomicrographs which accompany this note illustrate this fact clearly. *Fig.* 198 is a section of an external cartilage cyst stained with silver alone. The cover-slip was then removed, the section counterstained with hæmatoxylin, and the same area photographed again. The greater number of cells shown in the second photomicrograph (*Fig.* 199) needs no comment. It will be seen, further, that there is a definite aggregation of cells close to, and on, the surface.

FIG. 198.—Sections of a cyst of the external cartilage stained with silver alone.

FIG. 199.—Section of area shown in *Fig.* 198 after counterstaining with hæmatoxylin.

This, in our observations, is common in all the smaller cysts. Large cysts, admittedly, do not show the same appearance, possibly because they have reached full development and the unknown process which generated them has burnt itself out.

CONCLUSIONS

1. A further 20 cases of cysts in the semilunar cartilages of the knee-joint are reported—18 external and 2 internal.

2. Cartilage cysts may arise, as is now shown, from the free border of the semilunar cartilage and project into the joint, producing occasional 'locking' symptoms, with the sensation of 'locking' and followed by effusion into the joint.

3. Further experiences than those recorded in 1921 and 1929, and the use of other staining methods, still convince us that the smaller cysts can be shown to be lined by endothelium.

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ANGIOMA OF THE KIDNEY

REPORT OF A CASE WITH AN ANALYSIS OF 26 PREVIOUSLY REPORTED CASES

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BENIGN tumours of the kidney very rarely cause any clinical symptoms necessitating surgical interference, but villous papillomata of the renal pelvis and cavernous angiomata of the renal tissue may cause sudden and profuse hæmaturia which demands operation as an urgent life-saving measure. One of us (R.H.J.S.) reported a case of cavernous angioma of the kidney in 1921, since when other cases have been recorded, though in some the evidence is somewhat doubtful. A second case recently came under our care which is now reported, and an attempt will be made critically to review the cases previously recorded, and also to bring out a few points which may be of assistance in dealing with similar cases.

CASE REPORT

C. S. L., aged 15, a schoolboy at a well known Public School, commenced a fairly profuse hæmaturia on the morning of Nov. 2, 1934, unaccompanied by pain, frequency, vesical irritability, or pyrexia. Apart from some chest affection in childhood he had always been a strong and healthy lad, and there had been no previous attack of hæmaturia nor had there been any symptoms attributable to disease of the urinary tract. Three days prior to the onset of hæmaturia, he had sustained a kick in the scrotum whilst playing football, but recovered after a short interval and resumed the game and played a further game without discomfort two days later.

As soon as the hæmorrhage was reported, the boy was put to bed in the College Sanatorium and placed on a bland fluid diet. The temperature and pulse were normal; there was no swelling, no evidence of trauma nor tenderness in either renal angle. Neither kidney could be palpated. The subsequent history of the case and the investigations carried out are best given in chronological order.

Nov. 4.—Temperature and pulse normal, but hæmaturia persisted. The urine was heavily loaded with red blood-cells with a normal complement of leucocytes. No casts or pus were present, but a number of acid-fast and alcohol-fast bacilli were found in the centrifuged deposit, suggestive of tubercle bacilli. The specimen was not drawn by catheter, but a guinea-pig was inoculated from the deposit.

Nov. 7.—Hæmaturia still present but in diminished quantity. No rise in temperature or of pulse-rate, and no discomfort nor frequency in micturition. A catheter specimen of urine was examined, but no organisms were present and no pus cells found.

Nov. 10.—Hæmaturia now ceased and urine was bright and clear. Slides of the organisms reported on Nov. 4 were submitted to another bacteriologist, who was of opinion that they were not tubercle bacilli but a non-pathogenic streptothrix.

Nov. 14.—Blood examination showed:—

Red cells	6,000,000	Polynuclear basophils	1%
Hæmoglobin	98%	Polynuclear eosinophils	6%
Colour index	0·8	Lymphocytes	48%
Platelets	540,000	Monocytes	9%
Coagulation time	7 minutes	Red cells normal in shape, size, and staining reactions	
White cells	8400		
Polynuclear neutrophils	36%		

Nov. 18.—Further catheter specimens examined and no organisms found.

Nov. 20.—Patient allowed out of bed; hæmaturia recommenced without any other urinary symptom. Transferred to Edenbridge District Hospital.

Nov. 23.—Hæmaturia persisting. Cystoscopic examination. Bladder and ureteric orifices were normal. Blood in forcible efflux from left orifice; clear urine from right. Intravenous indigo-carmine appeared from each side in six minutes, rapidly increasing to a deep blue on right side and a black coloration on left side, due to admixture with blood. Transferred to London for further investigation.

Nov. 27.—X-ray examination. No evidence of renal calculus. A calcified tuberculous mesenteric gland gave a rounded, mottled shadow on the left side of the fourth lumbar vertebra.

FIG. 200.—Pyelogram obtained ten minutes after intravenous injection of uroselectan B. The upper calix of the left kidney is narrowed and mottled in appearance.

Intravenous pyelogram with uroselectan B (*Fig.* 200). Right shadow showed normal pelvis and calices. Left kidney—small bifid pelvis with clear lower calices, but the upper calix was elongated and ill-defined, with an area of irregular, mottled appearance suggesting tuberculous infection.

Urine: acid; specific gravity 1020; albumin in small quantity; blood discs present and numerous oxalate crystals. No pus cells, casts, tubercle or other organisms found. Blood:—

Red cells	4,720,000	Leucocytes	7000
Hæmoglobin	85%	Polymorphonuclear cells	61·7%
Colour index	0·9	Lymphocytes	33%

Nov. 28.—A low spinal anæsthetic was given in order to carry out an ascending pyelographic examination, but it was found impossible to pass ureteric catheters into either ureter for more than 2 cm.

Nov. 29.—X-ray examination of chest by Dr. Coldwell showed no evidence of tuberculous disease either in lungs or in the mediastinal glands. There was a small adhesion between the base of the left lung and the diaphragm.

Nov. 30.—The patient was awakened in the early morning by a severe pain in the left loin passing forward around the iliac crest to the groin, and followed later by marked hæmaturia with some clots. Consultation with Dr. Scott Pinchin, who could find no sign of active tuberculous disease in the chest. A culture from a throat swab showed no hæmolytic streptococci, but a Mantoux intradermal test was positive. The urine contained a quantity of blood, but no increase of leucocytes, and tubercle bacilli could not be found.

Dec. 6.—Bleeding continued in the urine in varying amounts—sometimes profuse, sometimes only slight. The boy was becoming decidedly anæmic, and, as it seemed that the

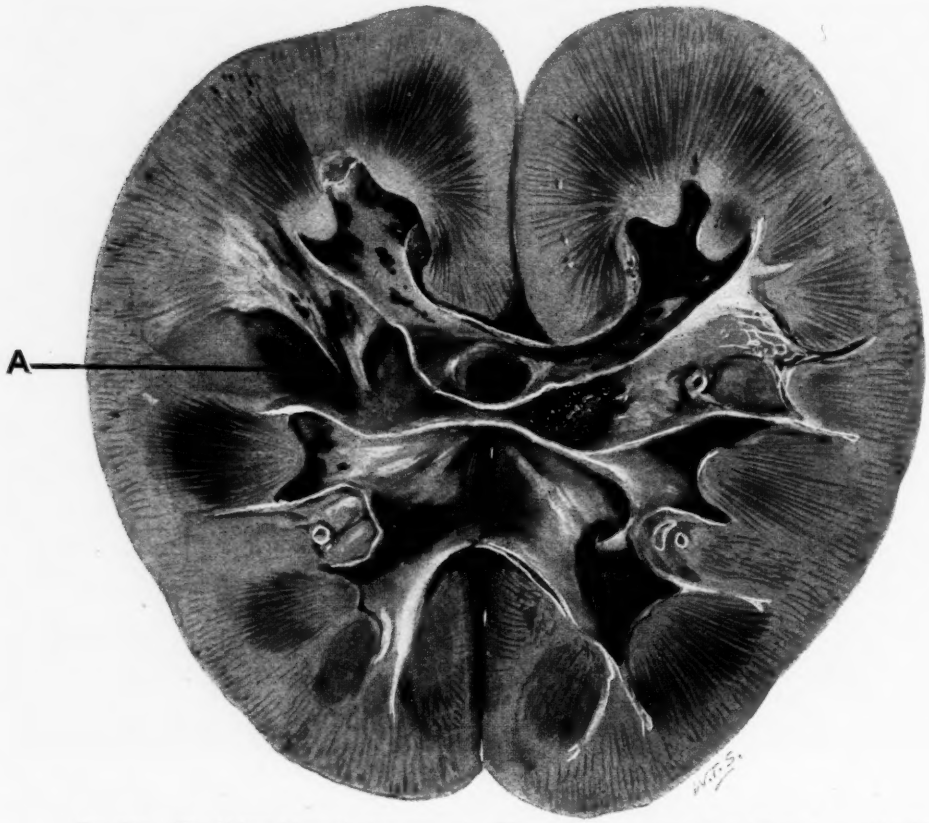

FIG. 201.—The kidney bisected after removal. The angioma is seen at A and there is considerable staining of the pelvis and subepithelial tissues from hæmorrhage.

diagnosis must rest between tuberculous disease and a hæmorrhagic tumour of the left kidney, operation was advised, and the patient was again transferred to Edenbridge District Hospital.

OPERATION (Dec. 12).—Evipan and gas and oxygen anæsthetic by Dr. Jarman. The kidney was rapidly exposed by an oblique lumbar incision, easily separated, and brought to the surface. It appeared to be quite normal. The ureter was not thickened and the pelvis appeared to be normal, although discoloured by contained blood. The upper pole of the kidney contained a small thickened area about the size of a large pea, which was thought to be a tuberculous focus; the kidney, together with the proximal 6 in. of the ureter, was therefore removed, and the wound closed with a small posterior drain.

Convalescence was uninterrupted and the patient made an excellent recovery.

PATHOLOGICAL REPORT.—For the following pathological report we are indebted to Dr. Hawksley :—

A kidney of normal size and contour. From urine (blood-stained) obtained from it before it was incised, films were made; another part was inoculated into a guinea-pig. The films were negative for tubercle bacilli and other organisms, and the guinea-pig, killed in the fifth week, showed no evidence of tuberculosis.

After fixation the kidney was bisected longitudinally (*Fig.* 201). The pelvis was bifid; the parenchyma was of healthy appearance. Pelvis and calices throughout were mottled with blood. In one of the upper calices, at one side of a pyramid, was a soft red mass of tissue, 10 by 4 mm. in diameter. Two pieces from this area and two from other parts were taken for section.

Microscopically (*Fig.* 202), there is no abnormality in the latter beyond a little subepithelial hæmorrhage. In the former there is evidence of the existence of a capillary angioma the tenuous walls of which have ruptured; the histological picture is complicated by extensive effusion of blood into the subepithelial tissue, largely masking the structure of the remaining intact capillary network. A feature of interest is the apparently intimate relation of the angiomatous tissue to vasa vasorum of arterioles in the connective tissue.

FIG. 202.—Microscopical section of the angioma and adjacent renal tissues at the point marked A in *Fig.* 201.

The neighbouring renal substance is of normal structure and entirely free from interstitial hæmorrhage.

A study of the various sections suggests that an abnormal proliferation of capillary blood-vessels, probably of developmental origin, has taken place immediately beneath the epithelium of the calix; rupture of these vessels has resulted in extravasation of blood into the pelvis and the subepithelial tissue.

DISCUSSION

In the consideration of this case we were presented with a patient of 15 years of age who had sudden profuse unilateral renal hæmaturia lasting for eight days and recurring after only slight exertion. The early report of the presence of acid-fast bacilli in the urine raised the suspicion of tuberculous disease in the kidney, whilst the subsequent findings on clinical examination of an old tuberculous calcareous gland, of an old adhesion between the pleura and the diaphragm, of a

positive Mantoux intradermal test, and of the mottled appearance of the upper calix of the kidney in an intravenous pyelogram were all points which lent support to this view. On the other hand, however, the complete absence of pus in the urine, the inability to find at any time after the first examination any bacilli in the urine, and the absence of any increased frequency of micturition, were points against the diagnosis of renal tuberculosis. The rapid excretion of indigo-carmine from the bleeding side of intense coloration was also unlike a tuberculous infection. The organisms first reported were also subject to suspicion as the urine containing them was not catheter-drawn, and was passed into a vessel which could not be guaranteed free from contamination, whilst the organisms themselves, though alcohol-fast (and therefore not smegma bacilli), were considered by one bacteriologist to be merely a non-pathogenic streptothrix. The fact that an organism so similar to the tubercle bacillus may be found under circumstances which would suggest a urinary infection is worthy of note.

We had therefore to consider other causes of unilateral renal hæmaturia. Hæmorrhage of purpuric origin was excluded by the blood-picture. Calculus in the kidney was unlikely, in the complete absence of any shadow taken in several X-ray films, whilst hæmorrhage from a toxic nephritis was negatived from the fact that both during and after the hæmaturia, bacteriological examinations of catheter specimens of the urine were sterile and that, in the absence of blood, no albumin or casts could be found; nor could any evidence of a focus of septic infection be discovered. That the blood came from the left kidney could not be doubted, as a blood-stained efflux was seen from the left ureter on more than one occasion in a full and forcible flow. The mucous membrane of the bladder was everywhere normal and showed no areas of submucous hæmorrhage nor any sign of papillomatous growth. The diagnosis seemed therefore to rest between an early tuberculous infection of the kidney and some form of neoplastic growth. Hypernephroma or carcinoma was unlikely, owing to the youth of the patient, whilst sarcoma or an embryonic tumour usually occurs in infants and gives rise to an easily palpable renal tumour. We could not exclude a villous papilloma of the renal pelvis in the pyelogram, but these cases are very rare and usually in older patients. The fact that the pyelogram showed a bifid pelvis suggested some congenital abnormality which might account for the hæmorrhage. In this connection it is worthy of note that in the cases of renal angiomata recorded by Kidd,[5] Bailey,[15] and Gayet, Gabrielle, and Martin,[18] it is definitely stated that a double or bifid pelvis was found.

The pyelogram in our case showed a small mottled area with ill-defined margin in the upper calix. A similar appearance has been noted in other cases by Jenkins and Drennan,[10] and by Gayet, Gabrielle, and Martin.[18]

We may be criticized for carrying out an operation without awaiting the result of the inoculation of the urinary deposit into a guinea-pig (which, as a matter of fact, subsequently proved negative), but the continuance of the hæmorrhage and the progressive anæmia of the patient rendered it advisable, though not an immediate necessity as in our earlier case. In any event, had the inoculation proved positive, nephrectomy would have been necessary, whilst if negative, the possibility of some form of growth would have rendered exploration and probably nephrectomy advisable. The other kidney having been proved functionally active, operation was therefore advised without further delay, after full and frank discussion with the patient's father.

The full pathological examination of the kidney after removal by Dr. Hawksley, Senior Pathologist to the Cancer Hospital, showed the presence of a capillary angioma with thin walls of flattened endothelial cells, which had ruptured, causing extensive blood effusion into the subepithelial tissues and into the renal pelvis. The tumour was situated at the side of the base of an upper pyramid, and is therefore distinct from the cases described by Fenwick,[19] Newman,[20] Simpson,[25] and others in which bleeding occurred from an angioma situated at the apex of a papilla.

REVIEW OF THE LITERATURE ON RENAL ANGIOMATA

There is very brief mention by pathologists of the occurrence of angioma in the kidney, but Stieda[24] states that Fukuda found two cases of angiomata of the renal parenchyma in the course of post-mortem examinations. The case described by Morris[1] was found in the kidney of a young woman who died from septicæmia, but who was known to have had occasional attacks of hæmaturia, lasting for three to four days, and pain in the left side for some years. In this case multiple angiomata were present, one of which had ruptured into the upper calix. Kaufmann[31] says they are very rare, and Kidd stated in the discussion following the exhibition of my first case before the Urological Seation of the Royal Society of Medicine,[2] that in a series of 2500 post-mortem examinations which he had personally conducted and in which he had particularly searched for renal angiomata, he had failed to find one; he had found adenomata and fibromata, but these had not given rise to clinical symptoms. Mackey[16] states that Muir had found no specimen of renal angioma at post-mortem examinations in Glasgow.

A careful search of the literature shows that 25 cases have been recorded, to which we now add another, and by the kindness of Mr. J. C. Anderson, of Sheffield, we are able to include a further case as yet unpublished, in this manner making a total of 27 cases (*Table I*). Of this number, 19 showed an angiomatous tumour in the kidney, occurring most frequently in the subepithelial tissue around the base of a pyramid, whilst in 8 cases the angioma was present at the apex of a papilla.

SYMPTOMATOLOGY

In the first case, which was operated upon in 1906 and described in 1921,[2] the hæmorrhage was very profuse in the first onset, and similar profuse bleeding from the onset is quoted by Wheeler[8], Jenkins and Drennan,[10] and Mackey,[16] demanding immediate operation, whilst in others quoted by Kidd,[5] Lutz,[6] Suter,[7] Gayet, Gabrielle, and Martin,[18] and Everidge,[14] there had been intermittent attacks of hæmaturia culminating in a more serious bleeding demanding operation.

It is interesting to note that in these cases of intermittent hæmorrhage, the attacks of bleeding had in some cases extended over many years, often after long intervals during which the patient appeared to be perfectly well. In Judd and Simon's case[11] the patient had had attacks of hæmaturia at intervals of four to five years for twenty years, being at times very severe, whilst in the careful report by Gayet, Gabrielle, and Martin[18] unilateral renal hæmaturia had been present for ten years, with intervals between the attacks of five and three years respectively, but becoming increasingly frequent. In Jenkins and Drennan's case[10] a patient aged 32 years had had attacks of hæmaturia at the age of 25 and 27 years, but was

Table 1.—RENAL ANGIOMATA

No.	Author	Age and Sex	Side	Symptoms	Operation	Situation of Lesion
1	Morris (1901)	23 F.	L.	Intermittent profuse hæmaturia and left lumbar pain for some years	—	Multiple angiomata one of which had opened into upper calix. Post-mortem specimen
2	Swan (1921)	19 M.	L.	Sudden very profuse hæmaturia for 3 days	Nephrectomy ..	Cavernous angioma of central portion of medulla and renal pelvis
3	Deansley. Reported to Swan (1921)	66 M.	L.	Intermittent hæmaturia and pain in left loin for 5 months	Local excision ..	Rounded angiomata on surface ½ to ¾ in. in diameter. One excised. Hæmaturia and pain persisted
4	Sennels (1922)	35 M.	L.	Hæmaturia and pain for one week	Nephrectomy ..	Angioma size of a pea in wall of pelvis
5	Kidd (1924)	19 M.	R.	Attacks of bleeding and colic for 10 years. Finally urgent	Nephrectomy ..	Subepithelial angioma of upper calix with hæmorrhage into renal tissue. Double ureter
6	Lutz (1924)	62 M.	R.	Hæmaturia for 5 weeks ..	Nephrectomy ..	Angioma size of cherry stone at junction of medulla and pelvis and under epithelium of calix
7	Suter (quoted by Lutz) (1924)	32 F.	—	Frequent hæmaturia for 1½ years, increasing in amount	Nephrectomy ..	Angiomata in wall of renal pelvis
8	Wheeler (1924)	37 M.	L.	Very profuse hæmaturia 6 days. No pain	Nephrectomy ..	Angioma 1½ cm. in diameter in wall of pelvis with extravasation of blood into renal tissue
9	Begg (1926)	33 M.	R.	Hæmaturia after a strain 2 years previously. Second attack nearly continuous for 6 months, becoming urgent	Nephrectomy ..	Lower pole of kidney occupied by a large blood cyst 11 cm. in diameter which was considered to be due to hæmorrhage from an angioma. Cavernous tissue found present in wall of cyst
10	Jenkins and Drennan (1928)	33 F.	L.	Attacks of hæmaturia at intervals of 2 and 6 years. Last profuse with colic	Nephrectomy ..	Angioma in upper pole 1 in. in diameter bulging into upper calix
11	Judd and Simon (1928)	57 F.	L.	Attacks of hæmaturia at intervals of 4 to 5 years for 20 years, sometimes profuse with colic	Nephrectomy ..	Angioma in upper pole of kidney 2½ by 1½ cm.
12	MacKenzie and Parkins (1929)	35 M.	L.	Hæmaturia for 10 days ..	Nephrectomy ..	Angioma surrounding and opening into upper renal calix with hæmorrhage into tissue
13	Gile (1929)	37 M.	R.	Frequent severe hæmaturia for	Nephrectomy ..	A tumour 6 cm. in diameter found on anterior

12	MacKenzie and Parkins (1929)	35 M.	L.	Hæmaturia for 10 days ..	Nephrectomy ..	Angioma surrounding and opening into upper renal calix with hæmorrhage into tissue
13	Gile (1929)	37 M.	R.	Frequent severe hæmaturia for 9 months, with colic	Nephrectomy ..	A tumour 6 cm. in diameter found on anterior surface of the kidney, and extending into pelvis. Cavernous angioma
14	Everidge (1930)	19 M.	L.	Intermittent hæmaturia for some years	Nephrectomy ..	Subepithelial angioma of pelvis
15	Bailey (1930)	31 F.	R.	Intermittent profuse hæmaturia for 2 years; 2 to 3 months intervals	Nephrotomy and decapsulation. Nephrectomy 2 years later	Angioma size of pea lying between two upper pyramids. Only found after multiple sections of kidney
16	Mackey (1930)	61 F.	R.	Profuse hæmaturia and colic for 8 days. Urgent	Nephrectomy ..	Small angioma of lower mid calix with surrounding hæmorrhage
17	MacKenzie and Hawthorne (1931)	30 M.	L.	Hæmaturia 8 years before. Recurred and persisted for 10 days, with colic	Nephrectomy ..	Angioma of pelvic wall
18	Gayet, Gabrielle, and Martin (1934)	33 M.	R.	Attacks of hæmaturia and colic for 10 years. Later profuse	Nephrectomy ..	Angioma 2 cm. in diameter in medulla and submucous tissue of upper calix
19	Swan and Balme (1935)	15 M.	L.	Hæmaturia for 8 days recurring after interval of 10 days	Nephrectomy ..	Subepithelial angioma of upper calix
Angiomata of Apex of Pyramid.—						
20	Fenwick (1903)	40 F.	R.	Continuous hæmaturia 2 years. No pain	1. Nephrotomy. 2. Nephrectomy 2 months later	Angioma of capillary type (Targett) of lower papilla
21	Newman (1913)	54 M.	L.	Frequent attacks of hæmaturia for 3 years, becoming profuse. No pain	Nephrectomy ..	Angioma like a mulberry mass in upper pyramid. Distinct limiting membrane
22	Baum (1913)	22 M.	L.	Intermittent hæmaturia for 10 years. Never pain	Nephrectomy ..	Angioma of apex of papilla
23	Rousing (1918)	—	—	Profuse hæmaturia	Nephrectomy ..	Angioma of papilla size of a pea
24	Burgess (1922)	26 F.	R.	Hæmaturia 4 days. No pain ..	Nephrotomy and excision of whole papilla	Capillary angioma. Remained well for four years
25	Stieda (1923)	29 M.	R.	Hæmaturia for 6½ years ..	1. Decapsulation. 2. Nephrectomy	Hæmorrhage continued after decapsulation. Angioma of papilla
26	Simpson (1926)	30 F.	R.	Profuse hæmaturia for 4 days. No pain	Nephrectomy ..	Small cavernous angioma of tip of papilla
27	Anderson (as yet not published)	45 M.	R.	Hæmaturia of varying degree for 7 weeks	Nephrectomy ..	Angioma of apex of papilla in uppermost calix

then free from bleeding for six years, when again a profuse hæmorrhage occurred. In Kidd's case[5] there had been attacks of profuse hæmaturia for ten years, but in the attack for which the patient came under observation the hæmorrhage was so severe as to demand immediate operation. In MacKenzie and Hawthorne's case[17] there had been only two attacks of bleeding at an interval of eight years. In just half the cases recorded the hæmorrhage commenced as an acute bleeding for which operation had to be undertaken owing to the fact that no treatment was effectual in controlling it.

Lumbar pain is mentioned as being present in addition to the hæmaturia in 11 cases, usually as distinct colic and probably due to the passage of blood-clot down the ureter. In 2 cases it is described as an aching pain. It is perhaps significant that of the 8 cases in which an angioma was found present at the apex of a pyramid, it was definitely stated in 7 cases that no pain was present at any time, whilst in the remaining one no mention was made of its presence. In 2 of this group the hæmaturia was serious enough to demand rapid surgical interference (Simpson[25] and Burgess[23]), and it is possible that the immediate admixture of blood oozing from the apex of a pyramid with the urine contained in the renal pelvis prevented any clotting or obstruction to the normal passage along the ureter.

The consideration of the age of the patient at the first onset of hæmaturia may be of some assistance in arriving at a diagnosis in these cases, and it is a significant fact that in the recorded cases the primary bleeding occurred comparatively early in life. Thus in 26 cases in which the age is stated the first attack of hæmaturia commenced as follows :—

			Per cent
Between	1–10 years	in 1 case	3·8
	11–20 „	5 „	19·2
	21–30 „	8 „	30·8
	31–40 „	7 „	26·8
	41–50 „	1 „	3·8
	51–60 „	1 „	3·8
	61–70 „	3 „	11·5

From the above table it will be seen that in 80 per cent of the recorded cases, the first appearance of blood in the urine occurred before the age of 40 years, whereas it is very unusual to find a hypernephroma or a carcinoma of the kidney before this age.

ANATOMICAL SITUATION OF ANGIOMATA IN THE KIDNEY

Although angiomata may occur in any part of the kidney, the majority of the lesions reported in the literature appear to be a cavernous or capillary angioma situated immediately beneath the mucous membrane lining the pelvis or one of the calices of the kidney, rupturing through the latter and giving rise to hæmorrhage. In many cases there is recent hæmorrhage into the immediately surrounding renal tissue, though in some reports mention is made of a limiting fibrous capsule. In 1 case a cortical angioma was resected from the kidney, but the hæmaturia persisted, and it is possible that in this case another deeper-seated tumour was present. In 4 cases a distinct angiomatous tumour was found on bisecting the kidney, after removal, but in each the tumour mass encroached upon the renal pelvis or a major

calix, and probably for this reason gave rise to hæmaturia. In 8 cases the angioma is reported to have occupied the tip of a pyramid of the kidney, giving rise to hæmorrhage severe enough to warrant nephrectomy in 7 cases, whilst in 1 case, reported in detail to me by Burgess,[23] the whole papilla, containing an angiomatous mass the size of a green pea, was resected and the patient remained free from any symptom for four years after operation.

Only in rare instances has a tumour been seen on the surface when the kidney was exposed at the operation, and most contributors state that the kidney appeared to be normal until it was bisected. In Deansley's case[3] there were several rounded nodules $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter on the cortex of the kidney, one of which was removed and reported by Targett to be an angioma surrounded by a fibrous capsule. The kidney was not removed and hæmaturia continued. In the case described by Judd and Simon[11] in which occasional attacks of hæmaturia had been present for twenty years, a tumour measuring $2\frac{1}{2}$ by $1\frac{1}{2}$ cm. was present in the upper pole of the kidney, whilst in Gile's case[13] a lobulated tumour measuring 6 cm. in diameter was found at the anterior surface of the kidney, but extending into the pelvis. Begg[9] removed a kidney containing a large blood cyst 11 cm. in diameter which was considered to be due to hæmorrhage from a renal angioma, cavernous tissue being found present in the cyst wall. In the remaining cases no tumour could be felt from the outside on exposure of the kidney at operation, which was necessitated in most cases by the severity or the continuance of the hæmorrhage which had been localized to one kidney.

DIAGNOSIS

The diagnosis of a renal angioma is very difficult and in most cases is made after the kidney has been removed for urgent hæmaturia. Practically all the recorded cases were proved to have unilateral renal bleeding, shown by cystoscopic examination and confirmed on subsequent examinations, and it remains to consider the various causes of bleeding from one kidney.

Hæmorrhagic nephritis can be excluded by the absence of casts or of albumin in the absence of blood, and the failure to find a marked septic focus, whilst the cystoscopic proof that the bleeding is unilateral and the frequent occurrence of one-sided colic from the passage of clots down the ureter will help to exclude it.

Tuberculosis would naturally be suspected in a young patient with unilateral hæmaturia, but will usually be excluded if the findings in the urine are negative, although the absence of small quantities of pus and of tubercle bacilli might be regarded as due to temporary closure of the infected calix. Repeated examinations of the urine and the complete absence of pus and of bacilli, together with the freedom from dysuria and increased frequency of micturition and the absence of any change in the ureteric orifice on cystoscopic examination, would negative tuberculous disease. Inoculation of guinea-pigs with the deposit of a suspected urine might be valuable in some cases.

Renal calculus may occasionally cause unilateral hæmaturia, even without pain, but with the present improved technique of radiology, very few calculi will escape detection on a good X-ray film.

Renal growth must be especially considered, particularly in patients over 45 years of age, but we find that nearly 80 per cent of cases of angioma occur before that age. In no case could any enlargement of the kidney be detected on deep

palpation in the loin, and it is improbable that a normal pyelogram would be obtained in any case of renal tumour.

Pyelographic examination was carried out in 9 of the 27 collected cases and some points arise which are worthy of discussion. Jenkins and Drennan[10] report a marked mottling in the position of the upper calix. Gayet, Gabrielle, and Martin[18] report a similar mottled appearance of an upper calix, and in our case now reported there was an irregular mottling in the upper calix which led support to the tentative diagnosis of early tuberculous infection. After the removal of the kidney in our case, the renal pelvis was again injected from the divided end of the ureter with sodium iodide solution, and probably with more tension than would have been used *in vivo*, but a radiographic film showed a normal outline of the bifid pelvis and calices and did not reproduce the mottled effect in the upper calix (*Fig.* 203). We

FIG. 203.—Pyelogram of the kidney obtained by injecting the divided ureter with sodium iodide solution after removal. The upper calices do not show the same mottled appearance as in the former pyelogram.

are inclined therefore to look upon this irregularity in the outline as due to adherent blood-clot at the time of the pyelography. In two cases the pyelograph showed no change from the normal, but in four a deformity of the pelvis or of a major calix led to a diagnosis of renal growth.

It is perhaps significant that of the 9 cases in which pyelography was carried out, a bifid pelvis was found in 3, whilst in a fourth case in which a kidney was removed by Kidd[5] a similar condition was present. Whether this abnormality may bear any relation to the presence of an angioma which may be etiologically due to some developmental vascular derangement must remain undecided. Gayet, Gabrielle, and Martin[18] consider that the presence of a bifid ureter would tend to support a suspicion of an embryological tumour in the kidney.

Unilateral renal hæmaturia may occur in association with *increased mobility of the organ*, often coinciding with attacks of acute renal colic or directly following some exertion, and is probably due to passive hyperæmia of the kidney from pressure upon or torsion of the renal vein. These cases must be carefully diagnosed from any form of renal growth, as the renal tissue is healthy and the fixation of the organ into its true anatomical position will effect a cure of the hæmaturia and save the kidney.

Hydronephrosis may occasionally be accompanied by unilateral hæmaturia, but the palpation of an enlarged kidney and the evident dilatation of the renal pelvis or calices on pyelographic examination will make the diagnosis obvious.

A series of cases of *varix of the renal papillæ* causing unilateral renal hæmaturia are described by Fenwick,[19] Newman,[27] Pilcher,[28] and others in which the veins of the papillæ are engorged and dilated and which have a tendency to bleed. These cases are not true angiomata and were cured by extensive nephrotomy and subsequent suture, the thrombosis of the veins by such operative interference arresting the bleeding. In some cases a wedge-shaped resection of the affected papilla was carried out, but the microscopic examination of the portion removed showed only engorged and dilated blood-vessels without any reference to angiomata. Newman, in his article, implies that the condition of renal varix has an entirely separate pathology to that of angioma.

In an article by Kidd[29] 24 cases of *purpura of the urinary tract* are analysed. All showed hæmaturia in varying amounts, and in 5 of these cases it was confined to one kidney, and Kidd suggests that the condition may explain many cases of painless renal hæmaturia. In one case of hæmaturia from vesical purpura, one kidney had been previously removed for unexplained hæmaturia, and in 6 cases in which nephrectomy had to be performed owing to the severity of the renal hæmorrhage, 3 subsequently had mild attacks of hæmaturia. In most cases the hæmaturia is accompanied by a streptococcal infection in the throat, nasal sinuses, teeth, or bowel, or by acute rheumatism, and the blood in the urine may be associated with purpuric areas in the skin or by bleeding from the gums, the nose, or the bowel. Bacteriological examination of the urine may be positive for organisms and the blood may show an absence or diminution of platelets. A case of unilateral renal hæmaturia from purpura of the renal pelvis requiring nephrectomy is reported by Ogier Ward,[30] but in this case no other sign of purpura was present.

In the reported cases of renal angiomata in which the hæmaturia was intermittent or in which it was not so profuse as to demand early operation, renal function tests were carried out by chromocystoscopy, when in every case it is reported that the dye was excreted within normal time limit, which is not surprising considering the very limited lesion usually found in the renal tissue after removal. The fact of a rapid elimination of good colour after an intravenous injection of indigo-carmine might be used as a differential diagnosis, as it is usually impaired quite early in tuberculous disease and often deficient with stone or growth. Where circumstances allow, every possible test should be carried out to estimate the functional efficiency not only of the kidney which has been proved to be bleeding, but also of the remaining kidney in case a nephrectomy may be required. These tests should include chromocystoscopy, intravenous pyelography, and the complete analysis of the urine obtained by ureteric catheterization, preferably carried out one and a half hours after the ingestion of 15 grm. of urea. In many cases, however, the abundance of the hæmorrhage does not allow of extended examination,

and in 13 of the collected cases it is definitely stated that the hæmorrhage was so profuse when the patient came under observation either in his first or in his most recent attack that, having been localized to one kidney, it was deemed inadvisable to delay operation, owing to the profound anæmia.

We feel, therefore, that in any case in which hæmaturia is localized to one kidney, is sudden and profuse, and is free from evidence of stone, tubercle, or growth, a renal angioma should be suspected, particularly in a patient of comparatively early age. We also feel that if complete examination of these cases of unilateral renal hæmaturia is made, the list of cases under the head of ' essential hæmaturia ' will be materially lessened.

TREATMENT

Any discussion on the treatment of renal angiomata is difficult owing to the great rarity of the disease and can only be outlined from general principles. The growth is an innocent tumour and the removal of the whole kidney seems an unnecessary sacrifice. In cases in which tuberculosis, calculus, and growth can be excluded and in which the hæmorrhage is only moderate, such measures as intrapelvic lavage with nitrate of silver or adrenalin might be tried, but where the bleeding is profuse and seems to endanger life, some surgical attack upon the kidney must be considered. The possibility of a malignant growth must be suspected in those cases in which complete pre-operative investigation has been impossible owing to the severity of the hæmorrhage. In such cases it would probably be advisable to proceed to an immediate removal of the kidney, together with the surrounding perinephric fatty tissue, rather than to risk the immediate spread of carcinomatous cells by an exploratory nephrotomy. Such treatment is also to be recommended when the general condition of the patient from profound anæmia will allow neither a prolonged operation nor one which is not certain of arresting the bleeding. In the remaining cases of proved intermittent unilateral renal hæmaturia in which the bleeding is less profuse and in which complete urological investigation has been carried out, growth, tuberculous disease, and calculus can almost certainly be excluded and a direct inspection of the renal pelvis may be undertaken by nephrotomy or by pyelotomy. In such cases a varix of a papilla or an angioma might be removed by endothermic resection and the kidney saved, but such favourable circumstances must be indeed uncommon. In most cases and especially when it is known that the remaining kidney is free from disease and functionally active, nephrectomy seems to offer the best chance of complete recovery.

SUMMARY

1. A further case of cavernous angioma of the renal pelvis is reported.
2. Twenty-six other cases have been collected from the literature.
3. The diagnosis of cases of unilateral renal hæmaturia is fully discussed.
4. The treatment of renal angioma is briefly discussed.

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THROMBOSIS FOLLOWING STRAIN

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PRIMARY thrombosis of normal veins in otherwise healthy individuals due presumably to trauma from muscular contraction has attracted considerable attention during recent years.

The vein in which the condition is seen is the axillary as a rule. Not unnaturally from what follows it is the vein of the right side that is usually affected, and the current theories of its causation are: (1) Cadenat's, that venous dilatation due to expiration combined with muscular strain injures the intima of the 'venous tributaries' at their junction with the axillary vein; (2) Lowenstein's, that venous dilatation due to expiration combined with marked abduction of the arm produces indentation of the axillary vein by the costo-coracoid ligament; (3) That of Pearce Gould and Patey, that sudden contraction of the subclavius muscle tears the subclavio-axillary valve in the long axis of the vein, especially in the abducted position of the arm and during marked expiration.

In nearly all the recorded cases a history of trauma could be elicited, and the condition has been called by Cadenat, 'phlébite par effort". Therefore it might be expected to appear in other veins. Recently I have seen two cases of primary thrombosis, the result of excessive muscular effort, affecting the thoraco-epigastric vein of the right side (*Figs.* 204, 205).

The patients were both healthy and in the prime of life, as is the case in axillary thrombosis, and in both there was little subcutaneous fat, so that the vein was both visible and palpable. In one, a male aged 30, the condition developed after digging in the garden, and in the other, a female, after shifting some heavy furniture. The symptoms were pain felt in the side of the chest wall and the discovery of a tender cord.

On examination a string-like band under the skin running up from the costal margin just behind the breast under the anterior axillary fold and disappearing in the axilla, was palpable and tender. In one of the cases there was obvious discoloration of the overlying skin, in the line of the vein. The physical signs cleared up completely in six weeks. The condition is of clinical interest, particularly in the female sex, because its close relationship to the breast may give rise to confusion in diagnosis.

Anatomically the vein is part of the venous tract represented by the lateral thoracic vein opening into the axillary vein above, the thoraco-epigastric vein, the connecting link, and the superficial epigastric of the abdominal wall below opening into the common femoral. This tract is of prime importance in blocking of either the superior or the inferior vena cava. In the upper part its valves deflect the blood to the axillary vein.

FIG. 204.—Infra-red photograph of the thoraco-epigastric vein in a normal subject.

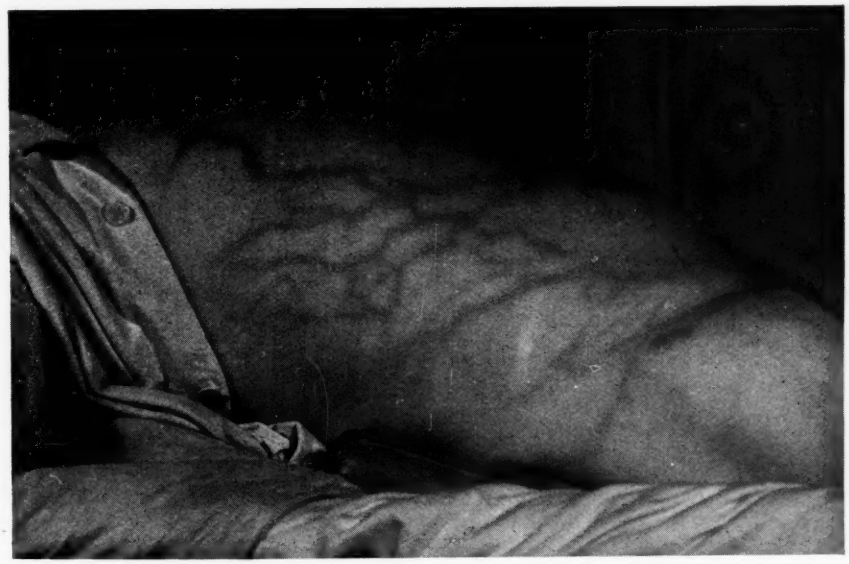

FIG. 205.—Infra-red photograph showing communication between the common femoral and the lateral thoracic vein in a case of thrombosis of the inferior vena cava.

As a cause of thrombosis one can postulate congestion and injury of the venous intima during contraction of the underlying muscles, possibly with injury of the valves in the lumen of the vein.

It is possible that the condition of axillary thrombosis may originate in this vein, the primary thrombosis being overlooked in the major condition affecting the axillary vein, especially as it is unlikely that the patient will draw attention to the original condition. In this connection both the patients were educated and observant people.

My senior colleague, Mr. C. Max Page, informs me that he has seen quite recently a similar case, but otherwise I am unaware of any record of the condition as a clinical entity.

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THE LATE RESULTS OF OPERATIONS ON THE BILIARY TRACT IN 359 CASES, WITH CHOLECYSTOGRAPHIC STUDIES IN 18 *

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SINCE the criterion of any operation lies in the ultimate benefit obtained by the patient, the greater the time which has elapsed since its performance, the more reliable the information will be on which to base an opinion of its merits or its shortcomings. It was decided, therefore, before this investigation was begun, that no case coming within its scope should have a post-operative history of less than ten years. In the hope of obtaining results in a number of cases sufficiently large to render justifiable any conclusions which might be drawn therefrom, the investigation was extended to cover the previous fifteen years, so that from ten to twenty-five years have elapsed since the cases in this series were operated upon. All of them were taken from the records of the Royal Victoria Infirmary, Newcastle-upon-Tyne, the honorary staff of which institution I wish to thank for the facilities accorded me.

Early in 1933 questionnaires were sent out to 790 patients who left hospital after having undergone operations on the biliary tract during the years 1907–22. The answers received amounted to 359, these including a considerable number from patients who came to the infirmary and reported to me in person and also communications from relatives or friends of those who had died. Thus about 45 per cent of patients were traced. Through the detailed consideration of these answers, certain statistics become available and later will be presented and discussed at some length.

Interpretation of the results of operation is always a matter of some difficulty, for there is much truth in the cynical observation that statistics can be made to prove anything. While admitting that the amount of benefit obtained is the true criterion of any operation, yet to estimate the relative values of different operative procedures one must have a basis of comparison. This basis must necessarily be the pathology present at the time of operation, for, unless this is the same in each case, results cannot be properly compared. In accordance with this premise, the cases in this series are grouped according to their pathology. The practical limitations to which this theoretically correct arrangement is subject become at once apparent, but, as will be seen, they are unavoidable at the present time. However, in spite of this, it is important that they should be given recognition.

It cannot be over-emphasized that the gall-bladder is not a separate entity

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* An investigation by the first holder of the Scholarship for Clinical Research founded in the University of Durham College of Medicine to perpetuate the memory of the late Mr. Hamilton Drummond.

but is only a specialized portion of a particular hollow muscular system, the biliary tract; that by far the greater part of this tract is intra-hepatic and therefore, at operation, is not available for examination. It is difficult to believe and, I think, wrong to assume that if infection is present in the gall-bladder, it will remain limited to that organ and not invade the unseen intra-hepatic portion of the biliary tract.

The ultimate effect of disease of the biliary tract is damage to the parenchymal cells of the liver, with resulting hepatic inadequacy. The condition of the liver, therefore, is of paramount importance in these cases, though little stress seems to have been laid upon it. The extent of any changes which the liver may have undergone cannot be ascertained, nor can the amount of damage it may have suffered be properly assessed. It is true that in the liver adjacent to an infected gall-bladder some degree of hepatitis may be evident. Does this extend beyond its macroscopic limit? We do not know. Does this hepatitis necessarily mean damage to liver function, and, if it does, is the amount of hepatitis proportionate to the degree of liver inadequacy? Again, we do not know. This hepatitis has been cited as an evident sign of liver change and presumably of damage, but if no visible change is present in the liver, can we assume that it has suffered no damage? I would hesitate to answer this question in the affirmative, for it is known that infection can be present in the bile-ducts to a marked degree without accompanying external change in the liver. How, then, are we to determine the amount of damage the liver may have suffered? The unfortunate truth is that until there is introduced a reasonably simple and reliable test for liver function we shall be compelled to forgo this most important knowledge.

Thus it will be seen that, in two given cases classed as acute or chronic cholecystitis, while the pathological change in each gall-bladder may be similar, the degree of invasion of the infection into the intra-hepatic portion of the biliary tract remains unknown. The consequent damage to liver function in the one case may be considerable, in the other negligible. For this reason the pathological basis of comparison is inadequate and must remain so at present. Moreover, this variation may explain the difference in the clinical results obtained after the same operation in cases where the apparent pathology was similar in degree and extent.

Furthermore, since pathology in other abdominal viscera may give rise to symptoms simulating those of biliary tract disease, it is quite possible that such pathology, having been overlooked at the time of operation on the biliary tract, may have a definite effect on the result obtained.

While these limitations should be borne in mind when considering results of operations on the biliary tract, yet we do not know to what extent they actually affect them. Nevertheless, this is no reason why attention should not be drawn to them, for it is only by their recognition that in due course they may be eliminated.

RESULTS OF OPERATION

These naturally are expressed in terms of the amount of relief obtained by the patient, and I have therefore elected to classify them by division into four groups —those who obtained: (1) Total relief; (2) Partial relief; (3) No relief; and (4) Those who have been subjected to a secondary operation on the biliary tract.

The fourth group consists of cases which, until the secondary operation, belonged to the second and third groups. The performance of the secondary operations, however, calls for the segregation of these cases into a group by themselves.

The use of the word 'cure' has been purposely avoided, for although many of those who have obtained total relief may actually be cures, yet the words are by no means necessarily synonymous. A true cure should not only mean total relief of symptoms—i.e., symptomatic cure—but should also indicate the absence of pathology similar to, or consequent upon, that for the relief of which the operation was primarily undertaken. For example, it is quite possible that, in a case of symptomatic cure following cholecystostomy, stones have re-formed silently in the gall-bladder. In a similar case after cholecystectomy, small stones may form in the smaller radicles of the biliary tract and pass down the common duct to escape into the duodenum without giving rise to symptoms. While such cases, then, can be grouped under the heading of 'total relief of symptoms', they are not cures in the true sense of the word and have no right to that name.

I have endeavoured to group the results according to this classification with all possible honesty, although realizing it is just as easy to obtain misleading results by being over-zealous in this respect as it is to do so by disregarding that virtue. The only cases put into the first group are those whose answers were unequivocal; on the other hand, several patients still complain of flatulence which, after all, might be due to causes other than mild persisting trouble in the biliary tract, yet it is by no means certain that even a full investigation would enable one to discover the etiological factor. However, such cases are regarded as failing to qualify for insertion into the first group. Several more, in the course of many years, have had only one or two attacks of recurrence of symptoms since their operation, with no interval or present symptoms, yet these attacks have precluded them from admission into the 'total relief' group. I feel that cases of this type sometimes find their way into the category of cures in statistics on this subject, especially if they are reported soon after operation before one of these attacks has occurred. This group of cases forms a subject for later discussion.

With regard to the assignment of cases to the second and third groups, there were a few of the border-line variety, and in these the personal equation was necessarily a factor.

Tables I to *V* are presented below, seriatim, for the convenience of the reader.

It will be seen in *Table I* that the number of cases in which the gall-bladder was removed is unfortunately small in comparison with that in which the organ was drained or closed, but this is no doubt accounted for by the fact that during

Table I.—GENERAL DATA

	GALL-BLADDER REMOVED	GALL-BLADDER DRAINED (OR CLOSED)	TOTALS
Questionnaires sent out ..	95	695	790
Replies	46	313	359
Died	5	49	54
Surviving cases	41	264	305

Table II.—Analysis of 305 Cases according to Pathology Present and Operation Performed

Pathology	Operation	
	Gall-bladder Removed	Gall-bladder Drained (or Closed)
Chronic cholecystitis with cholelithiasis ..	32	204
Chronic cholecystitis without cholelithiasis	0	9
Acute cholecystitis with cholelithiasis ..	9	51

Table III.—Results in 236 Cases of Chronic Cholecystitis with Cholelithiasis

Operation	Number of Cases	Total Relief	Partial Relief	No Relief	Secondary Operations
Cholecystectomy ..	31	19 (61·3%)	8 (25·9%)	3 (9·6%)	1 (3·2%)
Cholecystectomy and choledochlithostomy ..	1	1	–	–	–
Cholecystlithostomy ..	177	100 (56·5%)	37 (20·9%)	13 (7·3%)	27 (15·3%)
Cholecystlithostomy and choledochlithostomy ..	18	16 (88·8%)	1 (5·6%)	1 (5·6%)	–
Cholecystlithostomy and choledochostomy ..	2	2	–	–	–
Cholecystlithotomy ..	6	1	4	1	–
Cholecystlithotomy and choledochlithostomy ..	1	1	–	–	–

Table IV.—Results in 9 Cases of Chronic Cholecystitis without Cholelithiasis

Operation	Number of Cases	Total Relief	Partial Relief	No Relief	Secondary Operations
Cholecystostomy ..	8	6 (75·0%)	1 (12·5%)	--	1 (12·5%)
Cholecystostomy and choledochostomy ..	1	1	–	–	–

Table V.—Results in 60 Cases of Acute Cholecystitis with Cholelithiasis

Operation	Number of Cases	Total Relief	Partial Relief	No Relief	Secondary Operations
Cholecystectomy ..	9	7 (77·8%)	2 (22·2%)	–	–
Cholecystlithostomy ..	49	27 (55·1%)	16 (32·7%)	3 (6·1%)	3 (6·1%)
Cholecystlithostomy and choledochlithostomy ..	2	2	–	–	–

the period of time when these patients were operated upon, cholecystectomy had attained nothing like its present popularity. The deaths which have occurred will be discussed later.

From *Table II* it will be seen that of the 305 surviving patients there were only 9 (3 per cent) in whom stones were not found, chronic cholecystitis being the only pathology noted. There were no cases of acute cholecystitis without cholelithiasis, stones being present in the 60 in whom the gall-bladder was acutely inflamed.

The percentages of those who have obtained total relief of symptoms following operation, as seen in *Table III* (61·3 per cent after cholecystectomy and 56·5 per cent following cholecystostomy), appear to be rather low when compared with some others in the literature. Some of the probable reasons for this have already been indicated. However, if the percentages of patients who have received partial relief are added to those above, we find that 87·2 per cent following cholecystectomy and 77·4 per cent following cholecystostomy have been benefited by operation. These results, then, are not so unfavourable as they might appear at first sight.

While the percentages of those who obtained no relief from either of these operations are much the same, there is a striking difference in those representing cases which have come to secondary operation, there being 15·3 per cent after drainage of the gall-bladder and only 3·2 per cent following its removal. It is obvious, therefore, that the morbidity after cholecystostomy was considerably greater than that following cholecystectomy. The secondary operations performed on cases of this series form a subject for consideration later.

Those patients in whom the gall-bladder was closed after the removal of stones are only 6 in number; 5 of these have benefited by the operation, though only 1 has obtained total relief of symptoms. Although this operation is not often performed, yet it obviously has its uses, particularly in cases where the stones are of pure cholesterin and therefore metabolic in origin and the gall-bladder looks normal or only a very mild degree of chronic infection appears to be present in its wall.

Of the greatest interest are the results in those patients in whom the operative procedure on the gall-bladder was combined with drainage of the common duct. This latter operation was performed in 20 patients in whom the gall-bladder was drained, in 1 in whom that organ was closed after the removal of stones, and in another in whom cholecystectomy was done. Of the 21 patients in whom the gall-bladder was not removed, 19 (90·5 per cent) have obtained total relief of symptoms. The patient in whom drainage of the common duct was combined with cholecystectomy has also been completely relieved of symptoms. These results are so much better than those which followed only removal or drainage of the gall-bladder that it is important to investigate the factors responsible for their production. It was emphasized in a previous paragraph that the gall-bladder should not be regarded as a separate entity but considered as a portion of the biliary tract; that, in consequence, when the gall-bladder is the seat of an infection, this has probably also involved the unseen intra-hepatic portion of the tract in greater or less degree. It would seem, therefore, that either cholecystostomy or cholecystectomy is an inadequate procedure to deal efficiently with the pathology present, for is it to be expected that either of these operations alone can be productive of the best results when nothing is done to combat the infection in the intra-hepatic portion

of the tract and it is left behind as a residuum? We know that the principle underlying the treatment of infection of any hollow muscular system is the provision of adequate drainage. Where cholecystostomy has been performed, it is true that a drainage has been provided, but a valved and pathological cystic duct is liable to possess limitations as a channel for the unimpeded outflow of bile; direct proof of this lies in the fact that the daily amount of bile drained by cholecystostomy is considerably less than that in a case of common-duct drainage. On the other hand, where cholecystectomy has been done, no drainage at all has been provided for the infection lurking in the intra-hepatic radicles of the biliary tract. How, then, is adequate drainage of this portion of the biliary tract to be effected? Surely by drainage of the common duct, and this, I consider, satisfactorily explains the excellent results in this group of cases.

It is of interest that choledochlithiasis was present in 20 of these 22 cases, for a stone in the common duct is a complication which, by causing obstruction, leads to back-pressure and predisposes to infection of the obstructed bile. The resulting damage to the liver, however slight, cannot but have a detrimental effect on the individual and adversely affect the prognosis. It is impossible to say to what extent the liver was damaged in the cases under review, for even to-day we still have no means of measuring the degree of damage to the liver resulting from such a complication. The fact remains, however, that those cases in which its effects were combated on sound principles—namely, the removal of the obstruction and the provision of adequate drainage—have proved to be the most successful of the present series.

While the number of patients in whom stones were not found is small, as seen in *Table IV*, the percentage of those who obtained total relief of symptoms is definitely higher than in those cases with cholelithiasis. This is really to be expected, for cases such as the former no doubt represent an earlier stage of the disease. Hence these results seem to indicate that the sooner operation is undertaken the better will be the prognosis. Another patient is seen in this table in whom the common duct was drained and who has enjoyed total relief of symptoms since the operation.

The results in the small number of acute cases treated by cholecystectomy (*Table V*) are much better than those of the chronic cases treated by the same procedure. All patients are definitely improved and 77·8 per cent have obtained complete relief. These results are also much better than those in the same type of case treated by cholecystostomy.

A comparison of acute and chronic cases with cholelithiasis treated by drainage of the gall-bladder shows that, while the percentage of those who have obtained total relief of symptoms is about the same (55·1 per cent in acute cholecystitis and 56·5 per cent in chronic cholecystitis), yet that of cases with partial relief is considerably higher in the acute group. Consequently, we see that relief in some measure was obtained by 87·8 per cent of acute cases as compared with 77·4 per cent in which chronic infection was the pathology present. A possible explanation of these results may be as follows: in most cases of acute cholecystitis the gall-bladder shows a marked distension such as could not occur were the wall of the organ the seat of widespread fibrotic change. Since such change is the result of a chronic inflammation, it follows that most cases of acute cholecystitis occur at a relatively early stage of the disease.

In this table are a further two patients in whom the common duct was drained and who have obtained total relief of symptoms. This brings the total number of such cases in this series up to 25; of these, 23 (92 per cent) have obtained total relief, and 1 has obtained partial relief, bringing the percentage of those obtaining relief in greater or less degree up to 96. Such results are excellent.

ANALYSIS OF CASES WITH PARTIAL RELIEF AFTER OPERATION

First will be considered those patients in whom the gall-bladder was allowed to remain. They number 59, and the gall-bladder was drained in all except 4, in whom it was closed after the removal of stones. *Table VI* shows the time of recurrence of symptoms in these cases. In 8 cases, in spite of further inquiries, the answers received regarding the time of recurrence of symptoms were too indefinite to allow of their inclusion in this table.

Table VI.—TIME OF RECURRENCE OF SYMPTOMS AFTER CHOLECYSTOSTOMY IN 51 PATIENTS

TIME AFTER OPERATION	NUMBER OF CASES	TIME AFTER OPERATION	NUMBER OF CASES
Years		Years	
1	9	11	3
2	3	12	2
3	4	14	4
5	3	15	1
6	2	16	1
7	6	17	5
9	2	20	2
10	4		

An arresting feature of this table is that no fewer than 18 of these 51 cases, whose time of recurrence of symptoms is known, were well for ten years after their operation and therefore, up to this time, could have been grouped under 'total relief' or regarded as cures by those who adopt that nomenclature. These figures demonstrate well the fallacy of accepting results published too soon after operation.

There was mentioned previously the occurrence of a certain type of patient who, following an operation on the biliary tract, may have one or two subsequent attacks, at long intervals, of trouble suggestive of the recurrence of biliary tract disease, with complete remission of symptoms between the attacks, which apparently finally cease and leave the patient perfectly well. Eleven of the cases in *Table VI* belong to this category, and the details of their post-operative histories are disclosed in *Table VII.*

From a consideration of *Table VII*, the important question arises as to the pathology underlying these attacks. One most readily concludes that stones have formed again and that their attempted extrusion from the biliary passages is the source of trouble. There are three reasons, however, which tend to render invalid this explanation. In the first place, the great length of the intervals between the attacks is not characteristic of cholelithiasis. Secondly, the intervening freedom from symptoms is unlike the behaviour of gall-stones with their concomitant

chronic cholecystitis. Thirdly, and most important, in cases of this nature no evident pathology may be found on exploration. Since *the* cause of biliary colic is obstruction to the outflow of bile, it is suggested, because of the reasons mentioned above, that the cause of the obstruction in these cases is some factor consequent upon a transitory inflammation of the biliary tract, such as œdema or plugs of inspissated mucus or epithelial debris.

Table VII.—Post-operative History following Cholecystostomy in 11 Patients

Number of Case	Year of Operation	Post-operative History
1	1909	Biliary colic with jaundice 15 years after operation; a second attack 9 years after the first (early 1933); no other symptoms
2	1910	Biliary colic 17 years after operation; no previous or subsequent post-operative symptoms
3	1910	Biliary colic about 6 months after operation; no other symptoms
4	1916	Biliary colic 16 years after operation; no other symptoms
5	1917	Pain and flatulence "very bad" for 2 years after operation; no other symptoms
6	1917	Three attacks of biliary colic, first 6 months after operation, last in 1930. No symptoms between attacks; now perfectly well
7	1918	Gall-stone colic 11 years after operation; no other symptoms
8	1918	Biliary colic in 1931; no other symptoms
9	1921	Eight months after operation had intermittent pain and jaundice for 6 weeks; no other symptoms
10	1921	Pain, vomiting, and jaundice in 1924; similar attack in 1925; no other symptoms
11	1921	Biliary colic with jaundice in 1926; no other symptoms

It is important that wide recognition should be given to this type of case in order that unnecessary exploratory operations may be avoided. Because such cases do occur, it would seem that, where there is a post-operative recurrence of symptoms, be it early or late after operation, a policy of "wait and see" should be adopted, for there may be a return to the previous state of good health once the attack has subsided.

Table VIII.—Time of Recurrence of Symptoms after Cholecystectomy in 10 Patients

Time after Operation	Number of Cases	Time after Operation	Number of Cases
Years		Years	
1	4	11	1
3	1	16	1
4	1	20	1
9	1		

Concerning the symptoms complained of by these 59 patients, it was found that, while in 11 flatulent dyspepsia alone was present, and pain, vomiting, jaundice, and flatulence occurred together only in 3, the remaining 45 presented

various combinations of these symptoms. Actually, pain was the most frequent, occurring in 40, while in decreasing order of frequency there was vomiting in 35, dyspepsia in 19, and jaundice in 12.

The cases of this group in which the gall-bladder was removed are 10 in number. *Table VIII* shows the time of recurrence of their symptoms after operation.

Table VIII shows that 3 of these 10 cases were well for at least ten years following operation, and the remarks made previously concerning the 18 cases in *Table VI* apply also to these 3.

There is again evidence of a group of cases with a post-operative history of attacks, indicative of biliary tract disease, occurring at long intervals with intervening remission of symptoms. They are 6 in number and the details of their post-operative histories are given in *Table IX*.

Table IX.—Post-operative History following Cholecystectomy in 6 Patients

Number of Case	Year of Operation	Post-operative History
1	1908	Jaundice, lasting 5 to 6 months, beginning 6 months after operation; no other symptoms
2	1910	Biliary colic with jaundice in 1926; similar attack in 1932; no other symptoms
3	1913	Nine months after operation, intermittent pain and jaundice lasting 6 months; no other symptoms
4	1921	Biliary colic in 1930 followed by dyspepsia for some weeks; no other symptoms
5	1922	Biliary colic 3 months after operation; no other symptoms
6	1922	Biliary colic with jaundice in 1926 and 1932; no other symptoms

Since all these cases had their gall-bladders removed, the possibility of their isolated attacks being due to the passage of stones seems less likely than in those cases where the gall-bladder was only drained, for calculus formation in the liver is of comparatively infrequent occurrence. Should the condition of the liver be such as to favour this, one would expect a repetition of attacks of colic at short intervals. Because of the rarity of the attacks in these cases, it would seem that we must look for some other causative factor and it is suggested that this also is obstruction consequent upon a transitory inflammation of the biliary tract. Again, the advisability is obvious of adopting a " wait and see " policy in such cases.

The most frequent symptom complained of by these 10 patients was pain, which occurred in 8; vomiting was the next most frequent, occurring in 6 patients; and 4 have suffered from jaundice and flatulence.

ANALYSIS OF CASES WITH NO RELIEF FOLLOWING OPERATION

The patients in this group on whom a cholecystostomy was performed are 18 in number, and *Table X* shows the times of recurrence of their symptoms.

Since all these cases began to have recurrence of their symptoms within three years after operation, such early return of symptoms would seem to indicate that they are more likely to persist.

Table X.—Time of Recurrence of Symptoms after Cholecystostomy in 18 Patients

Time after Operation	Number of Cases
Years	
1	13
2	3
3	2

Of these 18 patients, all complained of attacks of pain and vomiting; jaundice has been present at one time or another in 7; and 12 have suffered from flatulence.

Passing to the patients in whom cholecystectomy was performed, we find that there are only 3. Symptoms recurred in all within a year after operation. All have suffered from attacks of pain and vomiting, 2 of them from dyspepsia, but jaundice has not occurred in any.

ANALYSIS OF DEATHS WHICH OCCURRED AFTER RECOVERY FROM OPERATION

In this series there are 54 patients who have died since leaving hospital; the causes of death were ascertained in 43 cases and they are given in *Table XI.*

Table XI.—Causes of Death of 43 Patients after Recovery from Operation

Cause of Death	Operation Performed	
	Cholecystostomy	Cholecystectomy
Cardiovascular disease :—		
Heart disease	7 } 9	1 } 2
Apoplexy	2 }	1 }
Carcinoma :—		
Œsophagus	4	
Stomach	1	
Colon	1 } 11	
Breast	1	1
Penis	1	
Affected organ unknown ..	3	
Pneumonia	2	–
Lung abscess	1	–
Pulmonary tuberculosis ..	1	–
Gastric ulcer	1	–
Ruptured peptic ulcer ..	1	–
Acute appendicitis	2	–
Diabetes	2	–
Subacute pancreatitis ..	1	–
Tuberculosis	1	–
Rheumatic fever	1	–
Renal disease	1	–
Strangulated hernia	2	–
Exophthalmic goitre	1	–
Cerebral tumour	1	–
Childbirth	1	–
'Eye trouble'	1	–

In 3 other cases the cause of death was stated to be " in no way connected with the operation."

From *Table XI* it will be seen that, while the causes of death are many and varied, carcinoma was responsible for 12 and cardiovascular disease for 11. It is of interest that the gall-bladder was not involved in the 9 cases of carcinoma in which the organ affected is known. One of the arguments put forward by the advocates of cholecystectomy is that an infected gall-bladder which has been drained is a potential focus of carcinoma. In the few cases of cancer of the gall-bladder upon which I have operated, the organ had not been previously subjected to operation, and I believe this to be the usual experience in abdominal surgery. While admitting that carcinoma does occur in gall-bladders which have been drained, the figures above seem to indicate that its incidence in these cases is certainly no greater than in those in which the organ has not been subjected to this surgical procedure. For this reason I feel that the fear of the onset of carcinoma should not be acknowledged as a valid objection to drainage of an infected gall-bladder.

Seven of the deaths of patients in whom cholecystostomy had been performed were due to heart disease, and the question arises of the possibility of these pathological gall-bladders having persisted as chronic foci of infection with a resulting myocarditis through systemic infection. Rosenow, of the Mayo Clinic, has satisfied himself that cultures of streptococci isolated from the walls of infected human gall-bladders are capable of producing myocarditis when injected into experimental animals. Further, it is known that in some instances systemic infection has cleared up following the removal of an infected gall-bladder—apparently examples of cause and effect. On the other hand, against the assumption that the gall-bladders in these 7 cases might have persisted as foci of infection there is certain clinical evidence, for it was reported in 4 that the operation was regarded as having been a perfect success during the time of the patient's post-operative survival. Again, the middle and late periods of life during which gall-bladder disease is prevalent are also those in which heart lesions manifest themselves. For these reasons, it does not seem justifiable to regard the drained gall-bladder as the essential etiological factor responsible for the heart disease in the above cases.

The baneful effect of disease of the biliary tract on the pancreas, although ordinarily given much prominence, does not appear to have been unduly detrimental in this series of cases. Pancreatitis was the cause of only 1 death and diabetes of 2. While admitting that the former might have been due to infection from the biliary tract, the incidence of diabetes amongst individuals who have no lesion of this tract is so great that its occurrence in these 2 cases must be regarded as much in the nature of a coincidence as an example of cause and effect.

The causes of death of the remaining 17 cases do not appear to bear any definite relationship to the infection of the gall-bladder for which the patient had been previously subjected to operation.

Inquiries were instituted to ascertain the length of post-operative survival of these 54 patients and their state of health during this period. *Table XII* shows the results of the first part of the inquiry.

From *Table XII* it will be seen that of the 49 patients in whom cholecystostomy was performed, 25 lived for at least ten years after operation, while of the 5 who had their gall-bladders removed, 3 survived longer than this period.

The results of the inquiry into the post-operative state of health of these patients are shown in *Table XIII*. It was ascertained in 33 cases only.

In the 9 patients in whom symptoms recurred, the data obtained were insufficient to enable them to be subdivided into the groups of partial or no relief.

Table XII.—Length of Post-operative Survival of 54 Patients

Years after Operation	Operation Performed		Years after Operation	Operation Performed	
	Cholecystostomy	Cholecystectomy		Cholecystostomy	Cholecystectomy
1	4	–	11	4	1
2	3	1	12	2	–
3	1	–	13	1	–
4	2	–	14	5	1
5	3	–	15	4	–
6	2	–	16	1	–
7	1	–	17	2	–
8	1	–	18	2	–
9	1	–	19	1	–
10	6	1	20	1	1
			22	2	–

Table XIII.—Post-operative Health of 33 Patients who Eventually Died

Operation Performed	Post-operative Health	
	Total Relief	Recurrence of Symptoms
Cholecystostomy	21	8
Cholecystectomy	3	1

The correlation of the information contained in *Tables XII* and *XIII* is not without interest. Of the 21 cases in whom cholecystostomy had resulted in total relief of symptoms, the time of death after operation varied from two to twenty-two years and no fewer than 12 had a post-operative survival of over ten years. The 3 patients on whom cholecystectomy had been performed with resulting total relief of symptoms lived for 11, 14, and 20 years respectively after their operations.

ANALYSIS OF SECONDARY OPERATIONS

The operations referred to under this heading are those which were performed only for a recurrence of symptoms similar to those for which the primary operation was undertaken. Since, from the point of view of the patient, the necessity of a second operation is a serious consideration, this group of cases is of the greatest importance.

There were 32 patients who had secondary operations performed; the first operation in 31 of these was cholecystostomy and in 1 cholecystectomy. Thirty-four operations were performed on these 32 patients, one of them having been

operated upon on three occasions for choledochlithiasis. The details concerning these cases are shown in *Table XIV*. Several aspects of this group present themselves for consideration and will be discussed forthwith.

Recurrence of Symptoms.—This took place from three weeks to twenty-one years after the first operation. In 14 cases symptoms recurred within one year, and within three years in an additional 7 cases. Four patients were perfectly well for at least ten years after their operation, one of these not having a recurrence of symptoms until twenty-one years had elapsed. Here, then, we again find evidence of a number of patients who obtained total relief from symptoms for at least ten years, although some subsequent development has arisen to prevent them from qualifying for inclusion in the 'total relief' group of the present series.

Pathology.—This, unfortunately, has not been reported fully in many cases, but certain data are available for consideration. In 7 patients the condition of the gall-bladder at both primary and secondary operations was noted. In 2 acute cases (*Cases* 13, 18), at the first operation it was distended, thickened, acutely inflamed, and contained stones; at the second operation in one of these patients (*Case* 13) it was found to be contracted and fibrosed and contained stones, while in the other (*Case* 18) it was healthy-looking and no stones were present. In 5 chronic cases the gall-bladder, at the first operation, was distended, thickened, and contained stones; at the second operation its condition was unchanged in 3 (*Cases* 7, 26, 28) and in the other 2 (*Cases* 10, 31) it had become contracted and fibrosed; stones, however, were present in only 3 of these cases at the second operation (*Cases* 7, 10, 28), being absent in one case where the condition of the gall-bladder was unaltered (*Case* 26) and in another in which the organ had become contracted and fibrosed (*Case* 31). These details appear to indicate that, while acute inflammation in a gall-bladder may undergo resolution, the probability of a chronic inflammation doing so is unlikely. In the latter instance the best that probably can be hoped for is natural cure by fibrosis, but the fact that stones were found again is presumptive evidence that the chronic inflammation was still persisting up to the time of the secondary operation in some of these cases.

Calculi were found in 31 of the 32 patients at the primary operation, being present in the gall-bladder on 30 occasions, and on another in the common duct. At the secondary operations calculi were found in 20 cases, 16 times in the gall-bladder and on 6 occasions in the common duct (three times in the same patient—*Case* 18). In the remaining 12 cases the absence of calculi is reported in 6, while in the other 6 their presence or absence was not noted. The discovery of calculi at a secondary operation on the biliary tract always raises the question of the 'missed' stone and of the extent to which it is responsible for the recurrence of symptoms. In many instances it is very difficult to know whether a stone found at secondary operation is one that was overlooked at the primary operation or one that has formed anew. In this respect the time relationship between pregnancy and the formation of calculi may be helpful, for clinical evidence shows that these can form within the nine months period of cyesis, so that if more than a few months elapse between operations a stone found at the second operation may be one of new formation; other considerations having some bearing on this problem are the size and number of the stones and, in the case of a single stone, the presence or absence of facets. Attention is drawn to 3 cases whose recurrence of symptoms was probably due to calculi which had escaped the

Table XIV.—Analysis of Secondary Operations

Number of Case	Date of First Operation	Pathology found at Operation	Time of Recurrence of Symptoms after First Operation	Date of Secondary Operation	Pathology found at Secondary Operation	Operation Performed	Result of Secondary Operation
Following Primary Cholecystostomy—							
1	1907	Stones in gall-bladder. None in ducts	12 years ..	1922	Adhesions. Gall-stones present. None in ducts	Cholecystectomy ..	Mild stomach trouble since
2	1909	Stones in gall-bladder. None in common duct	21 years ..	1930	Pocket of pus under scar. Gall-bladder not found	Drainage ..	No further trouble
3	1910	Stones in gall-bladder. None in common duct	1 year ..	1915	Large number of stones in gall-bladder	Cholecystlithostomy	Several attacks of pain since
4	1910	Many adhesions. Stones in gall-bladder	1 year ..	1912	Large chronic duodenal ulcer. Many adhesions in gall-bladder area	Posterior gastro-enterostomy	Fistula developed in 1913. Closed after few weeks. Pains at intervals ever since
5	1911	Stones in gall-bladder ..	16 years ..	1928	Numerous stones present in gall-bladder	Cholecystlithostomy	No further trouble
6	1911	Stones in gall-bladder ..	2 years ..	1922	One stone in gall-bladder	Cholecystectomy ..	No further trouble
7	1912	Gall-bladder distended and thickened. Evident signs of chronic cholecystitis. Numerous small stones in gall-bladder	Not known ..	1927	Multiple adhesions. Gall-bladder distended and thickened—about 20 stones	Cholecystogastrostomy	No further trouble
8	1913	Stones in gall-bladder ..	18 months ..	1925	Stones in gall-bladder, which showed thickening	Cholecystectomy ..	No further trouble
9	1913	Many small calculi in gall-bladder	16 years ..	1932	Gall-bladder small and shrunken: many adhesions. No stones in gall-bladder or ducts. Stomach and duodenum healthy	Separation of adhesions	Of benefit
10	1913	Gall-bladder distended and thickened. One stone present. None in ducts	"Shortly after"	1917	Gall-bladder contracted and fibrosed. Five stones found	Cholecystlithostomy	Attacks of pain at intervals. Further operation refused because of diabetes
11	1913	Gall-bladder wall thickened. Stones removed	2 years ..	1917	Gall-stones in gall-bladder. Encysted small pericholecystic abscess present	Cholecystlithostomy and evacuation of abscess	Free from pain for 6 years. Since then pain at intervals
12	1914	Stones in gall-bladder.	10 years ..	1925	Gall-bladder embedded	Cholecystectomy ..	Only trouble since

					small pericholecystic abscess present	abscess	then pain at intervals
12	1914	Stones in gall-bladder. None in ducts	10 years ..	1925	Gall-bladder embedded in dense adhesions. Small amount of clear bile in gall-bladder. No stones	Cholecystectomy ..	Only trouble since was one attack of pain in 1928
13	1915	Gall-bladder distended, thickened, and acutely inflamed. Containing purulent bile and stones	9 years ..	1931	Gall-bladder small, contracted, and fibrosed. Stones present	Cholecystectomy	No further trouble
14	1916	Stones in gall-bladder ..	4 months ..	1925	Distended gall-bladder, surrounded by dense adhesions	Cholecystectomy ..	No further trouble
15	1916	Stones in gall-bladder ..	8 years ..	1924	Adhesions. Gall-bladder chronically inflamed. Single stone blocking the cystic duct	Cholecystectomy ..	Still has periodic attacks
16	1916	Two stones in gall-bladder	Fistula for 6 months	1917	No pathology noted ..	Cholecystectomy ..	No further trouble
17	1919	Gall-bladder acutely inflamed and containing stones	3 years ..	1932	Gall-bladder containing mucin and many minute stones	Cholecystectomy ..	No further trouble
18	1919	Gall-bladder distended, œdematous, and inflamed. Bile purulent. Stones present	"Within a year"	1920	Gall-bladder healthy-looking. Two stones in dilated common duct	Choledochostomy	Now in good health
				1920	Two stones in common duct	Choledochostomy	
				1921	Gall-bladder flaccid. Wall somewhat thickened. Two stones in common duct	Choledochostomy	
19	1919	Single stone in gall-bladder	Not known ..	1923	Two stones in gall-bladder. Many adhesions	Cholecystlithostomy	No improvement. Much vomiting and pain
20	1920	Stones present in normal looking gall-bladder. No stones felt in common duct	3 weeks ..	1921	Adhesions. Small stones found in gall-bladder. None in common duct	Cholecystectomy ..	No further trouble
21	1921	No stones in gall-bladder. Stones in common duct, which was dilated to about 1 in. in diameter	3 years ..	1924	Gall-bladder shrivelled up. No stones. Common duct dilated. Stones in common duct	Choledochostomy	No further trouble
22	1921	Gall-bladder enlarged and tense. Many stones	2 years ..	1924	Adhesions. No stones in gall-bladder ..	Cholecystectomy ..	Still has attacks of pain and vomiting
23	1921	Gall-bladder containing stones	2 years ..	1923	Not known	Laparotomy ..	Of benefit

Continued on next page

Table XIV.—Analysis of Secondary Operations, *continued*

Number of Case	Date of First Operation	Pathology found at Operation	Time of Recurrence of Symptoms after First Operation	Date of Secondary Operation	Pathology found at Secondary Operation	Operation Performed	Result of Secondary Operation
24	1921	Stones in gall-bladder ..	4 months ..	1929	Adhesions between pylorus, gall-bladder, and anterior abdominal wall. Gall-bladder normal looking. No pyloric stenosis	Separation of adhesions	No benefit
25	1921	Gall-bladder surrounded by adhesions. Large number of stones. Pancreas normal	3 months ..	1921	Gall-bladder small and difficult to define owing to adhesions. Stone in cystic duct	Cholecystectomy ..	Has attacks from time to time
26	1922	Gall-bladder dilated and containing stones. Walls slightly fibrotic and thickened	2 months ..	1922	Gall-bladder thickened and dilated. No stones. Adhesions present	Cholecystostomy ..	No further trouble
27	1922	Gall-bladder small. Stones present	" Few months "	1922	One stone in gall-bladder	Cholecystostomy ..	No further trouble
28	1922	Gall-bladder distended. Walls slightly thickened. One stone	" Few months "	1924	Gall-bladder distended and thickened. Soft stones and inspissated bile	Cholecystostomy ..	Still trouble with vomiting and occasional jaundice
29	1922	Gall-bladder distended; numerous adhesions. No stones	7 months ..	1924	Adhesions present. Stone in common duct. No ulcer in stomach or duodenum. No stones in gall-bladder	Choledochlithostomy	Still has occasional trouble
30	1922	Gall-bladder small and contracted containing putty-like stones. None in common duct	8 years ..	1931	Not known	" Operation on gall-bladder "	Still has occasional trouble
31	1922	Gall-bladder distended and containing stones. Walls thickened	3 months ..	1933	Gall-bladder contracted and fibrosed. No stones. Many adhesions	Cholecystectomy ..	No further trouble
Following Primary Cholecystectomy							
1	1916	Gall-bladder wall white and firm. Many stones present	6 years ..	1929	Large stone in common duct	Choledochlithostomy	No further trouble

vigilance of the surgeon at the primary operation. In all these cases (*Cases* 20, 25, 16) stones were found in, and removed from, the gall-bladder at the first operation. In *Case* 20 symptoms recurred three weeks afterwards, and at the second operation, six months later, stones were found again. In *Case* 25 recurrence of symptoms took place in three months, and at the second operation, six months after the first, a stone was found in the cystic duct. *Case* 16, in which a fistula persisted after cholecystlithostomy until a secondary operation was undertaken six months afterwards, was probably also one of missed stone, but unfortunately no note was made of the pathology found at the second operation when the gall-bladder was removed. Another case (*Case* 29) deserves mention here; no stones were found at the first operation when cholecystostomy was performed, but symptoms recurred in seven months, and at the second operation, two years after the first, a stone was found in the common duct. This case leaves one wondering whether the stone was not overlooked at the first operation through the failure of the surgeon to explore the common duct.

Case 26 is of interest in view of the previously mentioned type of case in which a recurrence of symptoms takes place only to pass away and leave the patient perfectly well. Stones were found and removed at the first operation; recurrence of symptoms took place in two months and a second operation was undertaken six months after the first. The gall-bladder had not undergone any change and no stones were present. It was again drained and the patient has had no further trouble. The absence of pathology at the second operation and the subsequent good health of the patient lead one to think that the operation was undertaken perhaps unnecessarily.

The discovery of a large, chronic duodenal ulcer at secondary operation in *Case* 4, one year after cholecystostomy, provides evidence of the ease with which other pathology may be overlooked if not specially sought for, as it is almost a certainty that the ulcer was present at the time of the first operation. Its discovery also clouds the issue as to whether or not the gall-stones were the cause of symptoms in the first instance.

In the single case of secondary operation following cholecystectomy, a large stone was found in the common duct. The clinical features of the case—recurrence of symptoms as late as six years after the first operation and the lapse of another seven years before further exploration—seem on the whole to point to the stone being one of new formation. On the other hand, it is not impossible that its formation may be explained by the gradual augmentation of a small stone which was present in the unexplored common duct at the time when cholecystectomy was performed.

Perusal of the foregoing paragraphs makes it clear that the predominant pathology found at the secondary operations was cholelithiasis, characterized mostly by the re-formation of stones in the gall-bladder, although in at least three cases the calculi probably had been left behind at the first operation. In a small group chronic cholecystitis existed unassociated with stones. Choledochlithiasis, pericholecystic abscess, and duodenal ulcer were also observed. The presence of adhesions was reported in many cases; in two (*Cases* 9 and 24), at the secondary operation, the separation of these was all that was done. Since adhesions must form in every, or nearly every, case, including those which are completely relieved, it seems unlikely that they, *per se*, are the cause of a return of symptoms.

Clinical Histories following Secondary Operations.—It is important to know the amount of relief obtained from the second operation, and particularly is this knowledge of interest where the two operations differed in type. The details, such as are known, are to be seen in *Table XIV*, but they will be best appreciated by summarizing them.

Cholecystectomy was performed in 13 cases. Since operation, 8 (61·5 per cent) have obtained total relief of symptoms; 3 of these have a post-operative history of ten years of more, 2 of five to ten years, and 3 of under five years. Another patient reports "only trouble was one attack of pain in 1928" (three years after operation); a second, "mild stomach trouble ever since" (operation eleven years ago). Thus we may consider that 10 cases (77·0 per cent) of the 13 in which secondary cholecystectomy was performed have received relief from the operation. The remaining 3 of these cases still have a fair amount of trouble with periodic attacks of pain.

The 8 patients in whom the secondary operative procedure was cholecystostomy have not progressed nearly so well as those mentioned above after cholecystectomy. Three only (37·5 per cent) have obtained total relief of symptoms, 2 of these having a post-operative history of over ten years, while in the third, five years have elapsed since the second operation. The remaining 5 of these cases appear to have obtained little or no relief from their secondary operations, although 1 (*Case* 11) had freedom from symptoms for six years before they returned.

Choledochlithostomy was performed on 4 patients, 1 having had primary cholecystectomy and the others cholecystlithostomy. The first-mentioned has had no further trouble; of the second group of 3, 1 has obtained total relief of symptoms, another "still has occasional trouble", and the third, from whose common duct stones were removed on three occasions, reports that she is now in good health.

The meagre report on the pathology present in the patient in whom cholecystogastrostomy was done (*Case* 7) does not make clear the reasons why that particular operation was indicated. The patient, however, has experienced total relief of symptoms during the five years which have elapsed since the operation.

Separation of adhesions was done in two patients, in one with only partial relief, in the other with none. These results tend to confirm my belief that adhesions alone are not likely to be the cause of recurrent symptoms.

The few remaining cases do not present any features of particular interest.

THE EFFECT OF LENGTH OF OBSERVATION ON RESULTS OF OPERATION

So often in the literature one finds operative results compared with each other irrespective of the length of time of post-operative observation. The effect of taking this factor into consideration is strikingly brought out in the present series. There is also a natural tendency to accept the best results, invariably those of cases with a short post-operative history, as those which obtain in general, this giving rise to false impressions of the true value of operation and leading to future disappointments in practice.

On several occasions in the preceding pages attention has been drawn to patients who, although they are not included in the present group comprising those who have obtained total relief of symptoms, yet were in that category for ten

years following operation. The effect of incorporating these cases into the present results, and thereby obtaining results over a ten-year period only, is shown below.

Consider first the results up to the end of ten years in those 264 surviving patients (*Table I*) in whom the gall-bladder was drained or closed. There are 156 (*Tables III–V*) who have obtained total relief of symptoms since their operation, a percentage of 59·1. To these must be added those others who obtained total relief for ten years—namely, 18 of those who are at present grouped under 'partial relief' (*Table VI*) and 4 of those who came to secondary operation (*Table XIV*), making a total of 178 patients who were free from symptoms for ten years following operation. This number represents a percentage of 67·4—that is, 8·3 per cent greater than that when the period of observation was extended to cover twenty-five years.

Similarly, the results up to the end of ten years in patients in whom the gall-bladder was removed are as follows: to the 27 cases grouped under 'total relief' of symptoms (*Table III, V*) must be added 3 from the group of 'partial relief' (*Table VIII*), making a total of 30 cases free from symptoms at the end of ten years after operation. Since the number of surviving cases is 41 (*Table I*), the percentages represented by 27 and 30 cases are 65·9 and 73·2 respectively, a difference of 7·3 per cent in favour of the results for the shorter period of observation.

Five-year results are still better, and, when worked out on a similar basis to those above, it is found that the percentages of those surviving patients who obtained total relief of symptoms up to the end of this time are 74·2 and 78·0 for cholecystostomy and cholecystectomy respectively, representing increases of no less than 15·1 and 12·1 per cent over the corresponding figures when the period of post-operative observation was ten to twenty-five years.

It was seen (*Tables XII, XIII*) that several patients who eventually died lived for more than ten years after operation with total relief from symptoms. They were not included in the calculations above, however, for their number is small compared with that of the surviving cases and thus they would have made no material difference to the percentages obtained.

These figures indicate that we must not be content with a relatively short period of post-operative observation if the value of an operative procedure is to be properly assessed.

THE RELATIONSHIP OF LENGTH OF HISTORY TO RESULTS OF OPERATION

The possibility of the existence of such a relationship is worthy of investigation. In those patients in whom the gall-bladder was drained and whose pre-operative histories were recorded, 147 in number, it is interesting to find that of those who obtained total relief of symptoms 66 per cent had a pre-operative history of under one year; in those who obtained partial relief, only 38 per cent had a history of similar short duration; while of those who obtained no relief, no patient had a history of less than one year. In the cases of cholecystectomy, pre-operative histories recorded in 19 cases, the percentages for corresponding groups were 60, 25, and 0. These figures seem to indicate that a definite relationship does exist between the length of history and the result obtained, and that the sooner operation is performed following the onset of symptoms, the greater will be the

chance of obtaining a good result—a fact which is not sufficiently stressed at the present time. The realization of this is a most important consideration in the treatment of gall-bladder disease, for early operation enables the disease to be attacked before widespread involvement of the biliary tract has taken place. Furthermore, in early removal of gall-stones lies the most certain method of preventing the complications to which they are so prone to give rise. Nevertheless, these cases still continue to appear before the surgeon after having been treated by palliative injections of morphia for many years.

It is true that disease of the biliary tract may be symptomless for a long period, so that it cannot always be possible to attack it in an early stage. Also, the degree of virulence of an infection may vary considerably, with the result that a virulent infection of a short duration may produce as much damage as, or even more than, one of a mild degree which has persisted some time. This may explain why, in certain cases of this series, following either drainage or removal of the gall-bladder, total relief of symptoms was obtained although these had been present for many years, and why, in other cases, only partial relief was obtained where the onset of symptoms preceded operation by only a few months. These considerations, however, do not outweigh the advisability of early operation.

A REVIEW OF OTHER REPORTED SERIES

A search through the literature shows that there have been seven series published recently of late results of operations on the biliary tract—namely, those of Bernhard,[1] Connell,[2] Davis,[3] Judd and Priestley,[6] Mason,[7] Sanders,[9] and Young.[11]

In Bernhard's series (1933), the operations were performed between 1900 and 1915, and in all 500 cases drainage of the common duct was combined with removal of the gall-bladder. He does not give the actual number of cases followed up, but states that of this number only 30 per cent are completely free from symptoms, a result which is extraordinarily poor. He next gives a list of the various recurrent symptoms in 180 cases and ascribes these complaints to two sources: (1) Inflammatory or other changes in the biliary tract; and (2) Changes in the gastro-intestinal tract. Bernhard says that one can exclude the second group because these changes were also present before operation, and then he makes the strange statement that therefore 75 per cent are completely free from symptoms through operation. Secondary operations were undertaken in only 1·2 per cent of cases. He draws attention to the fact that one of the dangers of choledochostomy is a subsequent cicatricial stenosis, yet it is not mentioned as having occurred in any of the cases in his own series.

Connell (1928) reports on 99 surviving cases operated upon from 1910 to 1920. He found that in cases with stones, cholecystectomy gave better results than cholecystostomy, the respective percentages of cases without return of symptoms being 66·6 and 44·5. In non-calculous cases the corresponding figures were 75·0 and 77·3 per cent. There were 14 cases which came to secondary operation, the primary operation having been cholecystostomy in 13 and cholecystectomy in 1. It is of interest that in one of his cases, two years after cholecystostomy for calculous cholecystitis, a primary carcinoma of the gall-bladder was found. Secondary cholecystectomy was done in 7 cases, with relief in 4.

Davis (1928) follows up 144 cases of cholecystectomy, all done since 1921, so that

none of these has a post-operative history of more than seven years. Taking the series as a whole, 69·4 per cent were 'cured', but the results were definitely better in cases with stones (79·7 per cent cure in 69 cases) than in those without (60·0 per cent cure in 75 cases).

The most striking series is that reported from the Mayo Clinic by Judd and Priestley (1932). They deal with 606 satisfactory replies to questionnaires sent out to 1652 patients who were operated upon for disease of the biliary tract between 1907 and 1910, so that all have a post-operative history of more than twenty years. They found that cholecystectomy afforded results distinctly better than those following cholecystostomy in both calculous and non-calculous cases, the difference in 'satisfactory' results being about 24 per cent in favour of the former operation in each type of case, the average percentages being 84 and 60. No case of cholecystectomy came to secondary operation, while of those who had cholecystostomy performed, 17 per cent of calculous, and 12 per cent of non-calculous, cases were subjected to further operation. The predominant pathology found at these secondary operations was cholelithiasis, the calculi being found chiefly in the gall-bladder. Excepting that of Bernhard, this series is the only one in which results are mentioned in cases in which drainage of the common duct was employed. In calculous cases this procedure combined with cholecystostomy yielded satisfactory results in 76·8 per cent, and when performed alone or with cholecystectomy, 86·6 per cent gave a similar result. It was found that, following cholecystostomy, patients without stones had less subsequent trouble than those in whom stones were present, whereas after cholecystectomy the results seemed to bear no relationship to the presence or absence of stones. The results of an inquiry into the present state of health of 385 surviving cases suggest that the relation between disease of the gall-bladder or biliary tract and diseases of the joints or cardiovascular system seems quite definite, and the writers consider that the relatively large percentage of deaths in 65 cases which were due to cardiac disease and apoplexy confirms this association.

Mason (1931) has followed up 100 cases of chronic gall-bladder disease treated surgically by cholecystectomy five to fifteen years ago and another 100 which were given medical treatment during this period. He found that in the surgical cases 56·2 per cent stated that they were definitely relieved of all their old symptoms, and 83 per cent considered that operation had relieved 75 per cent or more of their previous complaint of pain. In contrast to these results, medical treatment completely relieved only 33 per cent, a similar percentage came to operation three to five years after the diagnosis of gall-bladder disease had been made, and the remaining third, because of the continuance of their symptoms, should have come to operation.

Sanders (1930) reports on 352 traced cases of cholecystectomy operated upon during the period 1921–8. He found that 84 per cent of these patients were completely relieved of symptoms and thinks that the removal of the appendix, carried out in the majority of these cases, may have favourably influenced the results, although Judd and Priestley found that appendicectomy made no difference. At the end of his article Sanders tabulates the results of 13 other series of cholecystectomies reported up to 1928. In 7 of these series the percentage of patients who are 'well' is between 80 and 90, in 4 it is between 60 and 70, in another over 90, and in the remaining one between 50 and 60.

Young (1928) reports results in 115 cases for a period ending 1925, this date therefore limiting the length of post-operative history of some of his cases to 3 years. Cholecystectomy was performed in all but 7 cases, in which cholecystostomy was done. He found that 63 per cent were 'cured', 22 per cent relieved of their main symptoms, and that 15 per cent were the same or worse. The 7 cases of cholecystostomy are all numbered amongst the cures, while all of those who have obtained no relief had their gall-bladders removed. The cystic gland was noted as being definitely enlarged in 13 cases, and as 8 of these belong to the group who were the same or worse after operation, Young thinks that such an enlargement suggests a focus of trouble elsewhere than in the gall-bladder.

A perusal of this review shows that several factors combine to render difficult, if not impossible, a satisfactory comparison of results. The same classification is not always used; the length of the periods of post-operative observation and the number of cases whose results are investigated are subject to considerable variation, and in some reports the degree of detail leaves much to be desired. However, one gets the impression that, on the whole, cholecystectomy gives definitely better results than cholecystostomy, both in regard to the actual percentage of cases benefited by operation and the possibility of the necessity of secondary operation.

CHOLECYSTOGRAPHIC STUDIES

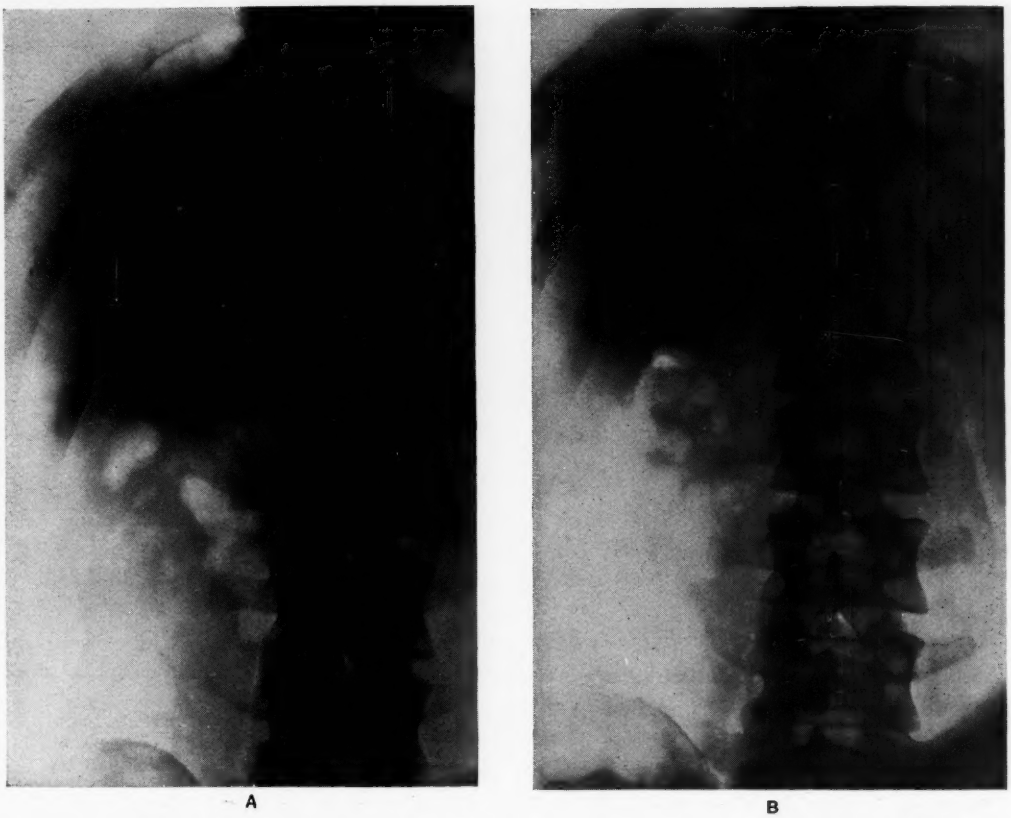
The amount of restoration of function that may take place in a diseased gall-bladder which has been drained is of great importance when considering the comparative value of cholecystostomy and cholecystectomy. The belief that little or no restoration of function takes place materially strengthens the claim for removal of the diseased gall-bladder as the treatment of choice except under conditions such as would render the more difficult operation of cholecystectomy an unjustifiable risk. It was in the hope of being able to confirm or refute this belief that this radiological investigation was undertaken. It was made possible through the co-operation of Dr. Whately Davidson, Honorary Radiologist to the Royal Victoria Infirmary, Newcastle-upon-Tyne, and to him and his technical staff my thanks are due.

At present the only means at our disposal of determining the function of the gall-bladder is by cholecystography, the method associated with the names of Graham and Cole, and one which, though subject to limitations, gives reliable information in a high percentage of cases. Since the general consensus of opinion and experience now is that intravenous administration of the dye yields no better results than when it is given by mouth, it was decided to administer the dye by the latter route, and a dose of 4 grm. of tetraiodophenolphthalein was given in each case. I am indebted to Mr. Foggin, Head Pharmacist to the Royal Victoria Infirmary, for his preparation of the dye in the form of a palatable beverage.

The following was the routine carried out. The patient was instructed to have the bowels thoroughly evacuated the day before the administration of the dye, which was taken, after the usual supper, at 9.0 p.m. just before retiring X-ray photographs of the gall-bladder were taken the following day at 9.0 a.m. and 3.0 p.m., i.e., twelve and eighteen hours after the ingestion of the dye. No food was allowed after taking the dye until the completion of the examination,

but no restriction was placed on the drinking of water during this time. A fatty meal was not given in the interval between the photographs, the routine in this respect following that advised by L. A. Rowden,[8] of Leeds, who, from his extensive experience, has found that if the gall-bladder fills and concentrates well, it also empties well. In consequence, he considers the giving of a fatty meal unnecessary.

Prior to submitting the patients to cholecystography, the writer himself underwent the examination in order to furnish a normal control for purposes of comparison. A very satisfactory result was obtained as can be seen from *Fig.* 206;



A B

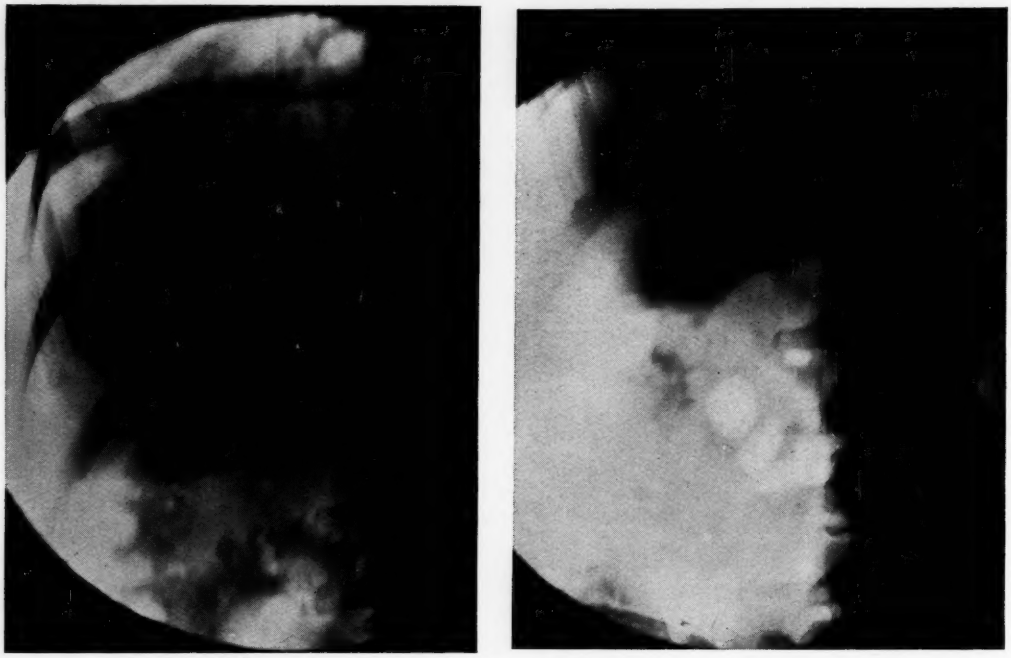
FIG. 206.—Cholecystogram of author for purposes of normal control. A (twelfth-hour film) shows the shadow of the gall-bladder to be of good and even density. B (eighteenth-hour film) shows an increase in both size and density of the shadow.

at the twelfth hour the shadow of the gall-bladder was of good and even density, and at the eighteenth it was slightly larger and the density had definitely increased, showing that the gall-bladder had both filled and concentrated well.

Arrangements were made for 50 patients of this series, all of whom had had cholecystostomy performed during the period 1907–22, to attend the Radiological Department as out-patients during the latter part of 1933. On completion of the cholecystograms it was found that only 24 patients had attended; of these, 6 had not taken the dye and therefore must be disregarded. This leaves 18 cases for consideration: the earliest cholecystostomy was done in 1911 and the latest in 1922, so that an interval of eleven to twenty-two years had elapsed since operation;

stones were found in every case at operation; in 14 cases the accompanying cholecystitis was chronic, and in 4 acute.

In brief, the results obtained were as follows. In 7 cases (38·9 per cent) the shadows were of good density on the first film and the density increased to such a degree on the second as to indicate that the gall-bladder was filling and concentrating well, these findings being interpreted as showing that the function of the organ was good; *Fig.* 207 shows a cholecystogram representative of those obtained in this group of cases. In 9 cases (50·0 per cent) the shadows were faint on the first film and little or no increase in density was shown on the second, these



A B

FIG. 207.—Cholecystogram. K. D. Cholecystostomy, 1922. Taken as representative of the seven gall-bladders with good function. Good shadow of gall-bladder in A (twelfth-hour film), with increased size and density in B (eighteenth-hour film).

findings indicating that the gall-bladder function was definitely impaired. In the remaining 2 cases (11·1 per cent) the gall-bladder was not visualized at all and so was considered to be a functionless organ.

The relationship between the function of the gall-bladder on the one hand and the clinical results and type of cholecystitis present at operation on the other are given in *Tables XV* and *XVI*.

It is of interest that both patients in whom the gall-bladder is a functionless organ belong to the group who have obtained total relief of symptoms following operation. One explanation of this seems to lie in the complete, or nearly complete, destruction of the mucous membrane by the inflammatory process which affected the gall-bladder. In this way the organ would be deprived of its power of absorption and so be unable to concentrate the dye. Moreover, in such cases the gall-bladder usually becomes a shrivelled-up mass of fibrous tissue with little or no lumen. If a small amount of secreting epithelium still survives, and if the

cystic duct still remains patent so as to allow the escape of the secretion into the common duct, then no symptoms are likely to arise from such a gall-bladder *per se*. The pathological picture, therefore, is that of a natural cure. A second explanation which might be offered also concerns a form of natural cure—namely, mucocele, due to complete obstruction of the cystic duct by such causes as calculus or stricture with resulting paresis of the gall-bladder wall. In such a condition the gall-bladder would also not be visualized by cholecystography owing to the

Table XV.—Clinical and Cholecystographic Results in 18 Patients after Cholecystostomy

Clinical Result	Gall-bladder Function		
	Good	Impaired	None
Total relief..	4	4	2
Partial relief	2	–	–
No relief ..	1	5	–

Table XVI.—Cholecystographic Results in 18 Patients After Cholecystostomy for Acute and Chronic Cholecystitis

Type of Cholecystitis	Gall-bladder Function		
	Good	Impaired	None
Acute ..	2	1	1
Chronic ..	5	8	1

dye-laden bile being prevented from entering the organ. However, the forcible contractions of the unstriped muscle of the gall-bladder wall which precede the subsequent paresis in such a case would probably have given rise to an attack of biliary colic. Furthermore, a mucocele of the gall-bladder has a tendency to become infected sooner or later, with recurrence of symptoms. Thus, of these two explanations, the former remains the more probable.

The presence of a normally-functioning gall-bladder after cholecystostomy in patients in whom there is a recurrence of apparent biliary symptoms is of importance as it suggests they may be due to causes other than disease of the gall-bladder and indicates the advisability of an investigation of other systems.

The percentage of cases showing normal function of the gall-bladder following cholecystostomy for acute cholecystitis is somewhat greater than that following this operation for chronic cholecystitis. While these results point in an expected direction, yet the number of cases is too small to permit of conclusions being drawn from them.

In these cholecystographic studies the length of time which had elapsed since operation was not found to bear any relation to the present degree of function of the gall-bladder.

While the present degree of function of the gall-bladder in each of these 18 cases, as shown by the cholecystogram, is known, a comparison of this with the pre-operative function is not possible, for cholecystography had not been introduced when the operations took place. While, therefore, the actual amount of restoration of function which may have taken place must remain unknown, one important fact is brought to light by the results obtained in this investigation. It is that in 11·1 per cent of the cases the gall-bladder is now functionless and in another 50 per cent the function is now definitely impaired. Thus, in the majority of cases, cholecystostomy has failed to restore the function of the gall-bladder to normal.

With regard to the 38·9 per cent of patients whose gall-bladders have now a normal function according to the cholecystograms, it must be borne in mind that one or more of these gall-bladders might have shown a normal response to the dye before operation, for cholecystography has taught us that such a result may be obtained if only a mild degree of inflammation of the gall-bladder is present. To assume that the function of the gall-bladder in the cases of this group was definitely impaired before operation and has thus been restored to normal by operation makes the present percentage of such cases much higher than that for similar ones reported by the authors quoted below. Even granting this assumption to be correct, there are still good reasons why this comparatively high percentage should not be regarded as an argument in favour of cholecystostomy. In the first place, it represents the minority of cases, and, secondly, we have not yet the means at our disposal of knowing which infected gall-bladder will have its function restored to normal by cholecystostomy and which will not.

It is interesting to make a comparison of these results with those of other reported series of cholecystograms following cholecystostomy. Spurling and Whittaker[10] carried out cholecystography, giving the dye intravenously, on 12 patients in whom an interval of twenty-five days to nineteen years had elapsed since operation. They found that the gall-bladder was visualized in every case, but none showed a normal shadow, so that all these patients had gall-bladders the function of which was impaired. In 4 cases the cholecystogram showed the presence of stones in the gall-bladder, and these findings were verified at subsequent secondary operation. In another 2 patients who came to secondary operation, the gall-bladder was found to be markedly thickened and sclerotic. These authors came to the conclusion that drainage of a diseased gall-bladder with the expectation that it will regain its normal function is not only a futile procedure but one that endangers the future health of the patient. Fleming[5] investigated the function of the gall-bladder by oral cholecystography in 36 patients whose average time since cholecystostomy was three years and ten months, the longest time being ten years and the shortest six months. He found a normal response to the dye in only 1 case, and in the large number of 29 the gall-bladder was not visualized at all, leaving 6 in which visualization occurred but was impaired. Thus his study indicated that the function of the gall-bladder was entirely lost in 80 per cent and impaired in 17·3 per cent of the remaining 20 per cent. Fourteen of the 29 cases whose gall-bladders were not visualized by the dye had been free from symptoms since their operation; the single normal response was found in a patient whose health had improved since operation though complete freedom from symptoms had not been obtained. Eliason and Ferguson[4]

undertook a cholecystographic study of 28 patients one or more years after cholecystostomy, the dye being given by mouth. In only 1 of 20 patients whose operative findings showed evident cholecystitis did the cholecystogram indicate a normally-functioning gall-bladder. In 8 of the patients studied the gall-bladder at operation appeared normal; 5 of these (3 non-calculous and 2 calculous) showed a normally-functioning gall-bladder, while in the remaining 3 (calculous), impaired function was noted. Their results lead these authors to the conclusion that cholecystostomy *per se* does not greatly alter the function of the gall-bladder.

SUMMARY AND CONCLUSIONS

1. An investigation was undertaken of the late results of operations on the biliary tract which were performed between the years of 1907 and 1922. Attempts were made to follow up 790 patients and were successful in 359, of whom 305 still survive.

2. The difficulties encountered in the interpretation and classification of the results are mentioned and discussed.

3. In both acute and chronic cholecystitis with cholelithiasis, cholecystectomy was followed by better results than cholecystostomy; the percentage of patients who obtained relief, both total and partial, being greater in patients in whom the gall-bladder was removed. Hence it is considered that cholecystectomy is to be preferred to cholecystostomy unless contra-indications to its performance exist.

4. Attention is drawn to the excellence of the results in cases with and without choledochlithiasis in which drainage of the common duct was combined with cholecystostomy or cholecystectomy. It is considered that an important factor in the production of these results is the additional drainage of the common duct. Thus a plea is made for the more frequent opening and exploration of the common duct in cases where the gall-bladder is the seat of marked inflammatory change, especially of the chronic type; it is the most certain way of ascertaining the presence of stones in this portion of the biliary tract and the exploration can be followed by drainage, thereby acknowledging the widespread nature of infection of this tract and applying the principle of treatment governing its eradication.

5. Several cases are reported which, after drainage or removal of the gall-bladder, had one or two or even three recurrent attacks over a long period of time, each attack subsiding and leaving the patient perfectly well. It is suggested that these attacks are due to a transient inflammation of the biliary tract. It is felt that wide recognition should be given to the existence of such cases in order that unnecessary secondary operations may be avoided.

6. In all the patients who claim to have obtained no relief from operation, recurrence of symptoms took place within a period of three years after operation, and, in the majority, before one year had elapsed. This seems to indicate that the earlier the recurrence of symptoms after operation, the more likely they are to persist.

7. An analysis of the causes of death which occurred in 43 cases of this series after leaving hospital shows that carcinoma and cardiovascular disease were responsible for the greater number. The fact that carcinoma of the gall-bladder did not occur in those patients who had cholecystostomy performed suggests that the drained gall-bladder is no more susceptible to carcinoma than one which has not been subjected to that procedure. Reasons are given why it is not deemed

justifiable to conclude that the deaths from cardiac disease were the result of a systemic infection due to the drained gall-bladder persisting as a focus of infection.

8. The percentage of patients who came to secondary operation after cholecystostomy was five times greater than that following cholecystectomy. The predominant pathology found at the secondary operations was cholelithiasis, characterized mostly by the re-formation of stones in the gall-bladder. In cases where primary cholecystostomy had been performed, secondary cholecystectomy has given much better results than secondary cholecystostomy. The increased liability to secondary operation which attends cholecystostomy and the possibility of the gall-bladder persisting as a focus of infection after this operation emphasize the importance of primary cholecystectomy as the operation of choice. The success of secondary cholecystectomy indicates that it is the best line of treatment to be adopted in these cases.

9. In so many patients a recurrence of symptoms did not take place until five or ten years following operation that figures for five- and ten-year results were compiled. The ten-year results are so much better than those representing the series up to twenty-five years after operation, and the five-year results correspondingly better than the ten-year, as to prove that results published after a relatively short period of post-operative observation should not be accepted as truly representative of the efficacy of operation.

10. A consideration of the length of pre-operative history of the cases in this series offers confirmatory evidence of an aspect of biliary tract disease which is not sufficiently stressed at the present time—namely, that the earlier operation is performed, the greater will be its chance of success.

11. Cholecystographic studies were made of 18 patients who had had cholecystostomy performed eleven to twenty-two years ago. In 61 per cent of cases the function of the gall-bladder is impaired or lost, indicating the failure of cholecystostomy to restore this to normal in the majority of cases. This is a further argument in favour of cholecystectomy as the treatment of choice of the pathological gall-bladder.

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TRAUMATIC RUPTURE OF THE CONGENITAL SOLITARY KIDNEY

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CONGENITAL absence of one kidney is uncommon, but Eisendrath[2] has shown that it is not of extreme rarity. He found in his series that it occurred in 0·1 per cent of autopsies, and he was able to trace the records of forty cases. Males predominated. The solitary kidney was more commonly on the right (in our series every case was left), and was usually, but not invariably, in the normal position: it was found to be hypertrophied, sometimes to double the normal size.

A true unilateral kidney is usually associated with a single unilateral ureter and a single opening into the bladder, but in 7 per cent of cases some trace of the opposite ureter may be found (Thomson-Walker[7]). There may be no trace of the ureteral orifice, or this may be marked by the presence of a small dimple, but in some cases an orifice has been found to be present opening into the lumen, which extends for 1 or 2 cm. along the fibrous cord which represents the ureter. This half of the trigone of the bladder may be atrophied.

The frequency of the absence of the suprarenal gland on the side of the missing kidney appears to vary considerably in different series. Eisendrath[2] records 10 to 25 per cent in various reports; Thomson-Walker[7] states that it is absent in 27·7 per cent of cases. The renal vessels are usually absent or quite rudimentary. The condition may be associated with genital abnormalities (Eisendrath[2] and Brattström[1]).

A number of cases have been reported in which nephrectomy has been performed on account of a neoplasm or disease of a kidney, which proved later—at post-mortem examination—to be of the congenital solitary type. In contradistinction to this a thorough search of the literature has disclosed but four reported cases of traumatic rupture of the congenital solitary kidney. An analysis of these cases is shown in *Table I*, and to these is now added a fifth.

CASE REPORT

HISTORY.—S. D., a schoolboy aged 12, on the morning of Oct. 29, 1932, fell off a gate about 5 ft. high on to his left flank. He was taken home and put to bed. He complained of pain in the left loin, vomited several times, and passed blood in the urine. Later he was seen by his doctor, who found that his abdomen was rigid on the left side, and sent him up to the Royal Sussex County Hospital for admission.

ON ADMISSION (9.45 p.m.).—Intelligent boy; pale; no air-hunger. Temperature 96·8°, pulse 100, respirations 20. Abdomen moved slightly, but this and coughing were painful. No sign of shifting dullness. The percussion note was impaired, increasing to absolute dullness in the flank (*Fig.* 208). Urine: small specimen, almost pure blood.

Table I.—Analysis of Cases of Traumatic Rupture of Congenital Solitary Kidney

Author and Date	Sex and Age	Occupation	Side of Kidney	Nature of Accident	Nature and Time of Operation	Day of Death (after Accident)	Notes
1. Melchior[4] (Germany) 1928	M. 27	Doctor	L.	Motor accident	1. Laparotomy. 2. Nephrectomy. Day after accident	5th	On admission general condition good. Bruising in L. flank. Bladder contained pure blood; next day worse. Anterior laparotomy showed some distension, but no intraperitoneal injury. Hæmorrhage round L. kidney. Wound closed. Lumbar nephrectomy. Kidney showed deep transverse cut into hilum
2. Speer[5] (U.S.A.) 1929	M. 27	'An Italian'	L.	Motor accident	Nephrectomy soon after admission	Soon after 1st day	Conscious on admission. Also fracture of L. femur. Very shocked, but improved a little, so operation. Kidney showed complete tear into pelvis and vein
3. Brattström[1] (Sweden) 1932	F. 16	Schoolgirl	L.	Kicked by horse while bicycling	Nephrectomy soon after admission	3rd	On admission bladder full of pure blood. Condition rapidly deteriorated, so operation performed. Kidney found to be pulped. At post-mortem examination no ureter or suprarenal present, and uterus bifid
4. Thompson[6] (Ireland) 1932	M. 22	?	L.	Kicked in L. loin at football	Nephrectomy several days after accident	10th after operation	This patient was watched for some days, first at home and then in hospital before the persistence of pain and bleeding demanded operation. L. kidney showed deep cut into pelvis and was 'hopelessly' damaged
5. Turton and Williamson (England) 1932	M. 12	Schoolboy	L.	Fell about 5 ft. off gate on to L. flank	Drainage of retroperitoneal extravasation 11th day after accident	11th	Expectant treatment at first and patient improved, but then became worse. (*See* case report and photograph of kidney)

COURSE.—

Oct. 30–Nov. 6.—The condition improved gradually. The patient began to feel and look better, although he was still very ill. He complained of pain, severe at times, in the left flank. The area of impaired percussion note started to recede into the flank. The urine increased in amount, and became less blood-stained. (The output on Nov. 2nd and 5th was 43 and 30 oz. respectively.)

Nov. 6–9.—After becoming clear the urinary output lessened and soon stopped. A catheter showed the bladder to be empty. The general condition became worse. He complained of pain, suprapubic, and in the left iliac fossa and left loin, and there was an ill-defined tender swelling in these regions. He became drowsy.

A diagnosis was made of an infected extravasation of urine and blood, around and below the ruptured left kidney —producing anuria—and a simple drainage operation was decided on.

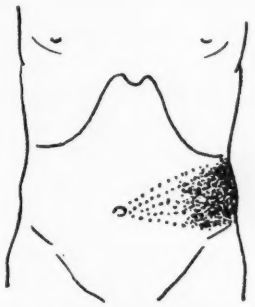

FIG. 208.—Diagram showing area of diminished percussion note in case of ruptured solitary kidney.

OPERATION (Nov. 9).—Under a general anæsthetic a left gridiron incision was made near the anterior superior iliac spine. A large amount of urine (proved chemically later), and some clots were rapidly evacuated from the extraperitoneal tissues below the left kidney. A drainage tube was inserted and another through a stab-wound in the left loin. As this was finishing the heart and respiration stopped. Although these were restarted, after thirty minutes they stopped again—finally.

FIG. 209.—Post-mortem appearances of left kidney and ureter, and of bladder. A, Lower pole of left kidney showing extensive laceration; B, Atrophic right side of bladder; C, Internal urethral orifice; D, Probe in left ureteral orifice (note this lies between two areas of submucous hæmorrhage); E, Left ureter.

POST-MORTEM EXAMINATION (by Dr. L. R. Janes).—

Left Kidney.—Rupture extending from the capsule to the pelvis at the lower pole. Much perinephric extravasation of blood, with some retroperitoneal extravasation extending to the opposite side of the abdomen, and down into the pelvis with commencing organization.

Right Kidney.—Absent together with ureter.

Right Suprarenal.—No trace found.

Bladder.—Right ureteral orifice absent, left natural. Right side of trigone atrophic (*Fig.* 209). Some small ecchymoses on the subperitoneal surface of the bowel and bladder (patchy in distribution and independent of retroperitoneal extravasation). No hæmoperitoneum. Operation drains in good position for drainage of lower pole of kidney. Much bruising of perineal and scrotal region. No scar of any previous operation seen (such as nephrectomy).

Spleen, Liver, and Thorax.—No injuries.

COMMENTARY

In *Case* 5 the diagnosis was up to a point correctly made—rupture of the left kidney—and the patient was watched and treated as such. As his condition improved it was thought that the rupture was not sufficiently severe to need immediate or early operation. The possibility of the absence of the right

kidney was never considered, nor was nephrectomy proposed when operation became imperative.

Three questions arise: (1) Whether an attempt should be made in every case of kidney injury to determine the presence or otherwise of a functioning second kidney. (2) If this is considered desirable, is it possible, and what means are available? (3) If the damaged kidney is proved to be the only functioning organ, what is the most appropriate line of treatment?

1. Although a search of the literature has discovered only five cases (including that now reported) of rupture of a single kidney, the incidence of congenital single kidney as shown in Eisendrath's[2] statistics is not so rare as to render it probable that these are the only cases in which rupture of a solitary kidney has occurred. It would appear likely that many less severe, and therefore non-fatal, cases of rupture of a solitary kidney have gone unreported, and in all probability the unilaterality was not suspected. It would therefore seem desirable that the presence of a functioning kidney on the other side should be proved or disproved.

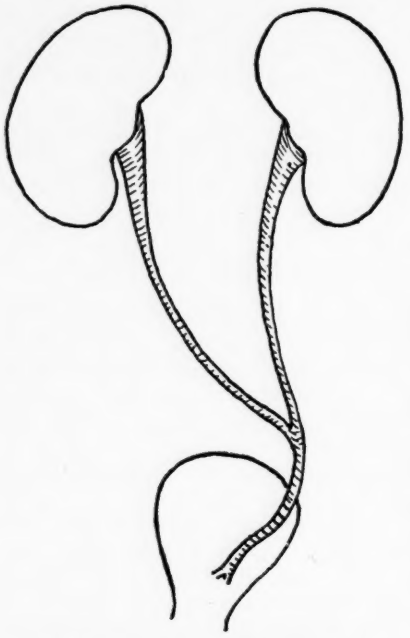

FIG. 210.—Diagram of Hepburn's case, in which the two ureters united to end in a single ureteral orifice. (*After Eisendrath.*)

2. The possible means of ascertaining the presence of a second functioning kidney:—

a. Cystoscopy in these cases is usually very difficult owing to hæmorrhage continually obscuring the view of the ureteral orifices (Melchior[4]). Moreover, even if a clear view is obtained and hemiatrophy of the trigone and absence of one orifice is proved, the case might be one of rupture of one kidney in a patient, such as the one described by Hepburn[3], in which there was a single ureteral orifice normally located but two kidneys, the ureters from these having united before entering the bladder (*Fig.* 210). Cystoscopy, therefore, even if possible, is of little practical value in any case, whatever its degree of severity, and moreover is scarcely justifiable owing to the very definite risk of conveying infection (Thomson-Walker[7]).

b. Intravenous pyelography does not appear to have been done in any of these cases, but at any rate in the less urgent cases it would seem to offer the only pre-operative means of determining the presence of a second functioning kidney. There would not seem to be any contra-indication to its employment in such a case.

c. Unless it has been possible by intravenous pyelography to prove the presence of a functioning contralateral kidney, the peritoneum must be opened and *palpation of the opposite renal fossa* (and if empty, below this, in case the other kidney is ectopic) can and should be done before nephrectomy. This method is available in the most urgent type of case, especially in those very severe ones in which anterior laparotomy is performed owing to the possible injury to other viscera.

3. The answer to this question is sufficiently obvious. If the only kidney is damaged, every effort should be made to arrest hæmorrhage by conservative suturing or partial nephrectomy.

CONCLUSIONS

1. A case of rupture of a congenital solitary kidney is quoted and four other cases are tabulated.

2. Rupture of congenital solitary kidney is distinctly rare.

3. It occurs most commonly in men, usually on the left side and in young patients, the figures in this series being: Males to females, 4 to 1; left to right, 5 to 0; average age, 21 years.

4. Unless the rupture is slight, when the diagnosis of a congenital solitary kidney has not been made, the condition has not been suspected, and has only been found post mortem.

5. In any case of renal injury, where nephrectomy is contemplated: (*a*) Where the condition of the patient permits, intravenous pyelography should be employed as a means of demonstrating the presence of a second functioning kidney; (*b*) In the severe type manual palpation for the contralateral kidney must be employed at operation.

6. If the rupture is proved to be that of a solitary kidney, the operative measures adopted must be conservative.

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SQUAMOUS-CELL CARCINOMA OF THE RENAL PELVIS: REPORT OF A CASE

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Tumours of the renal pelvis form 5 to 7 per cent of all renal tumours,[1] and these in turn form ½ to 2 per cent of all tumours, occurring in about 1 in every 400 patients.[2]

Ewing[3] has divided these tumours into: (1) Benign papilloma; (2) Papillary epithelioma; and (3) Flat or alveolar carcinoma. The last group would include the squamous epithelioma type, but amongst the group would also be included the advanced cases of papillary epithelioma where the papillæ had become so flattened and compressed together as to render their original papillary formation indistinguishable.

Kretschmer[4] collected 43 cases of non-papillary carcinoma, of which 17 were thought to be epidermoid. Since then cases have been published by, amongst others, Wells[5] (1 case), Scholl and Foulds[6] (5 cases between 1907 and 1922 at the Mayo Clinic), and 1 case each by Keynes,[7] Wheeler,[8] Herman and Greene,[9] and Bowen and Bennett.[10] Jocelyn Swan,[11] in a personal series of 65 cases of new growths of the kidney, had 2 cases of papillary carcinoma, 2 of squamous epithelioma, and 1 of benign papilloma. Cabot and Allen[12] collected 27 cases of malignant renal pelvic tumours at the Mayo Clinic between 1923 and 1932, of which 24 were papillary, 2 non-papillary, and 1 was a mixed papillary and sessile tumour. Swift Joly,[13] in a collected series of 337 cases of renal pelvic tumours, found 120 cases of benign papilloma, 138 cases of papillary carcinoma, 29 cases of transitional-cell carcinoma, and 50 cases of squamous-cell carcinoma.

In view of the comparative rarity of non-papillary carcinoma (squamous epithelioma) of the renal pelvis, it was thought of interest to put on record an additional case, especially since it was unassociated with the presence of any stone or gross renal infection.

CASE REPORT

History.—The patient, a married man of 54, by occupation a coppersmith, was admitted to hospital with the history of having been perfectly fit, apart from an attack of malaria sixteen years previously, till three months before. At this time he had some vague pain in the lower part of his back on both sides. This he treated himself, and it passed off after about a week. About a month later he started with renal colic on the right side; at first the pain was ill-defined, but after a day or two it became severe. Associated with the pain he had hæmaturia, slight frequency which he attributed to an increased fluid intake, and some strangury. The condition improved after a few days. Six weeks later and just prior to his admission he again passed blood with his urine. On this occasion the pain was in the lower abdomen and equally severe on the two sides. There was no definite colic. He said he had lost over two stone in weight during the past three months.

On Examination.—The patient had obviously lost weight. The right kidney was palpable and felt rather hard, but moved normally on respiration. There were no signs of disease elsewhere.

Microscopic examination of his urine revealed the presence of some blood, occasional pus cells, and many *B. coli*. The non-protein nitrogen of the blood was 37 mgrm. per cent.

A cystoscopy was carried out. The ureteric orifices were normal, blood was coming out of the right. Indigo-carmine excretion test showed dye appearing from the left orifice in six minutes and from the right in ten minutes. A pyelogram on the right side showed the lowermost calix attenuated and deviated to one side, the remainder of the pelvis appearing normal. Uroselectan examination showed a possibly slight hydronephrosis on the *left* side, whilst on the right the lower calix was not seen, the remainder of the kidney apparently excreting normally.

FIG. 211.—Macroscopic appearance of tumour. ($\times \frac{2}{3}$.)

DIAGNOSIS.—A diagnosis of malignant disease of the kidney was made and operation decided on.

OPERATION. The kidney was explored through a right renal incision. It was only very slightly if at all bigger than normal, and adherent at the lower pole. A number of firm smooth glands extended from the pedicle upwards to the region of the liver. The lower pole was separated and the kidney removed, though it was really inoperable in view of the glands.

Convalescence was uneventful, the patient feeling much better after the operation, but at the time of discharge three weeks later he was beginning to go down hill, and he died two months after the operation.

EXAMINATION OF SPECIMEN.—The kidney was seen to be replaced at the lower pole, where it had been adherent, by a greyish-white tumour nodular at one point. On section the tumour was seen to involve the lower part of the pelvis and lower calix and to be spreading into the substance of the kidney, involving rather less than its lower half. At the periphery of the growth were separate scattered foci in the substance of the kidney (*Fig.* 211).

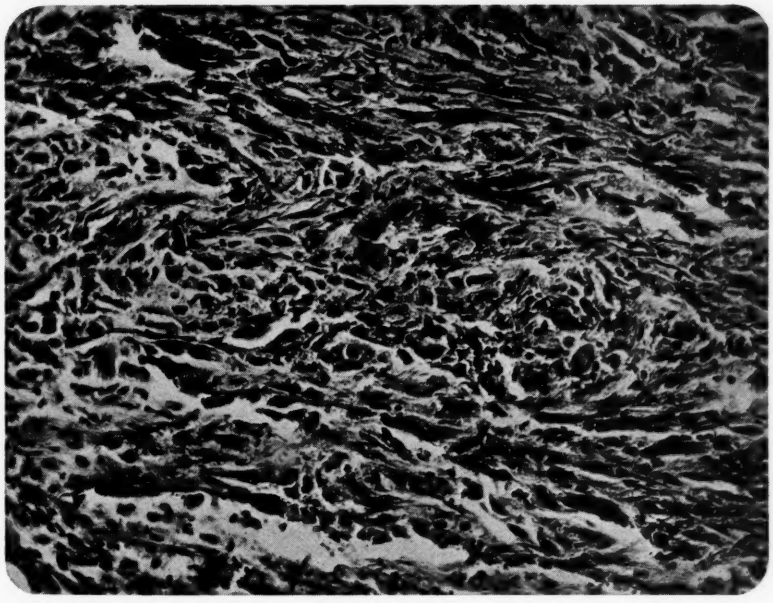

FIG. 212.—Section of tumour showing mixed- and spindle-celled type of growth. (× 190.)

Microscopical examination of the growth was interesting. A section taken from the growing edge showed cells resembling those in a spindle- or mixed-celled sarcoma in part,

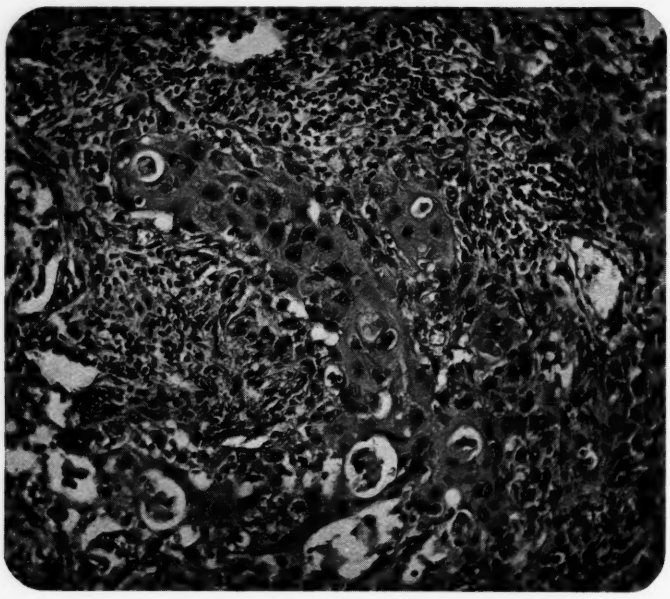

FIG. 213.—Section showing typical carcinomatous area. (×135.)

FIG. 214.—Gradation between *Fig.* 212 and *Fig.* 213. (×135.)

whilst the arrangement elsewhere was reminiscent of a carcinoma (*Fig.* 212). Further sections were therefore cut and these showed the tumour to be a highly malignant anaplastic carcinoma arising from the pelvis. No cell nests were seen (*Fig.* 213). A further section

(*Fig.* 214) shows the gradation between the typical carcinoma (*Fig.* 213) and the anaplastic sarcoma-like area (*Fig.* 212). There was no history of stone, and none was found, nor was there any gross infection of the kidney.

DISCUSSION

Etiology.—The condition is twice as common in males as in females, and 50 per cent of the cases occur between the ages of 40 and 60.[14]

As elsewhere in the urinary tract, squamous epithelioma arises from epithelium that has undergone metaplasia due either to infection, prolonged or of short duration but acute, or to chronic irritation, usually from stone. Of the cases collected by Kretschmer[4] 11 were associated with stone, 4 of the 5 cases reported by Scholl and Foulds[6] were associated with stone, as were the cases reported by Wells,[5] Keynes,[7] Wheeler,[8] and Bowen and Bennett.[10] Jocelyn Swan[11] in his series had one case with stones and one without. The cases collected by Cabot and Allen[12] were unassociated with stone, as was the case reported by Herman and Greene,[9] where the growth obstructed the pelvis of the kidney, producing marked hydronephrosis. Graham Simpson[15] mentions the possibility of one of his cases having been a non-papillary carcinoma arising from the renal pelvis, and this was unassociated with stone.

Herman and Greene suggest that the tumour may arise from developmental inclusions of ectodermal cells, but feel that chronic irritation or infection is the usual predisposing factor. Pascual,[16] however, considers infection not to be important etiologically, as he would have expected tuberculous disease of the kidney to be more commonly associated with carcinoma.

Pathology.—There are two types of tumour. In one, of which the case reported is an example, the renal parenchyma is invaded early, the kidney being replaced by carcinoma. As the growth passes to the periphery the epithelium becomes more anaplastic, more rapidly growing and primitive, so as to resemble a carcinoma simplex. This is commonly associated with stone. In the second type the renal pelvis is covered by numerous tumour masses some of which may be papillary: the pelvi-ureteric junction is obstructed by growth so that the kidney, which is not invaded, and the pelvis become hydronephrotic, and the kidney tissue atrophies.

The case described by Keynes[7] is of interest. There a calculous pyonephrotic kidney was removed and the patient returned with recurrence of swelling three months later. It was noticed that there was some granulation tissue at the site of the scar, and a section of this showed cells resembling those of a round- or spindle-celled sarcoma. Re-examination of the removed kidney showed a plaque which microscopically proved to be squamous epithelioma. In the case reported the anaplastic carcinoma at the growing edge of the growth resembled a spindle-celled sarcoma. The case described by Keynes is the only one that could be found to have a similar type of cell, though in his case it was in a recurrence.

Metastases.—In both types these are early and widespread. They invade the local lymphatic glands extending to the liver. Metastases also take place by the blood-stream and are found in the liver, lungs, and bones. In non-papillary carcinoma there is no tendency for implantation to occur lower down in the urinary tract.

Clinical Course.—The cases associated with stone usually have a long history, that of stone, and then perhaps an increase in the severity of the symptoms may make one suspect the onset of neoplasia. Hæmaturia in the non-papillary type occurs in about half the cases.[9] The relative infrequency of this symptom is probably due to the fact that the tumour does not tend to ulcerate deeply and in a certain proportion of cases obstruction takes place at the pelvi-ureteric junction. In the majority of published cases there has been a marked loss of weight; the patient reported lost two stone in three months. The kidney may be palpable and may be much enlarged; in the latter case this is often a result of the preceding infection or calculous disease.

Although diagnosis of the exact microscopical lesion is difficult, the association of hæmaturia with marked loss of weight should make one suspect malignant disease. Unfortunately in a proportion of cases attention is not drawn to the kidney until the condition is inoperable.

Prognosis.—This is bad. Of eight cases of squamous-celled carcinoma on whom nephrectomy was performed reported by Kretschmer, five died soon after the operation and the remainder developed metastases early. Of the cases collected by Scholl and Foulds, one died eleven days after the operation, two two months after, and one, which was partly papillary and partly sessile, died four and a half years later. Of the three cases reported by Cabot and Allen, one lived eight months and died from stomach trouble, one died within ten days and had metastases in the liver, and one was reported well two months after the operation. The diagnosis of non-papillary or squamous-celled carcinoma of the renal pelvis carries with it a hopeless prognosis, the average duration of life being between ten and eleven months, though that in the papillary type of growth would appear to be more favourable, thirty-seven months (Cabot and Allen[12]).

I am indebted to Professor T. B. Davie and Dr. Hugh Smith for the microscopical report on the tumour.

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SACRO-COCCYGEAL CYSTS AND TUMOURS

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The sacro-coccygeal region is one of the commonest sites in the body for the occurrence of anomalous cysts, sinuses, and tumours of various kinds. This is not surprising when the complex nature of the development of this part of the body is taken into account. Reference is made to the changes occurring in the caudal extremity of the primitive streak, to the formation and disappearance of the neurenteric canal and the post-anal gut, and to the formation of the terminal part of the intestinal tube by the development of the anal canal. Complicated changes also occur in connection with the genito-urinary system. It is possible that any of these primitive structures may leave a relic of their existence and furnish a contribution to that which has been described as a histological potpourri.

EMBRYOLOGICAL FEATURES OF THE SACRO-COCCYGEAL REGION

In the early stages of development the caudal end of the body is the site of very rapid and complex changes. The primary tissue of the entire digestive system is entoderm, and this forms a tube which extends first into the head region as the fore-gut and later caudally as the hind-gut (*Fig.* 215). The fore-gut becomes the mouth, pharynx, and a portion of the small intestine. The hind-gut forms the colon, rectum, and part of the small intestine. The region between these two extremities is the mid-gut, which opens ventrally into the yolk sec. At each extremity the entoderm gut comes into direct relationship with the ectoderm, and fusion occurs between these two layers with the formation of the oral and cloacal membranes. The hind-gut forms a subterminal dilatation which is bounded on the dorsal aspect by the aorta and notochord and ventrally by the ectoderm of the body wall. It is on the ventral wall of the cloaca that the cloacal membrane is formed (*Fig.* 216). The hind-gut and allantois open into the anterior wall of the cloaca; the meso-nephric ducts open into the dorso-lateral

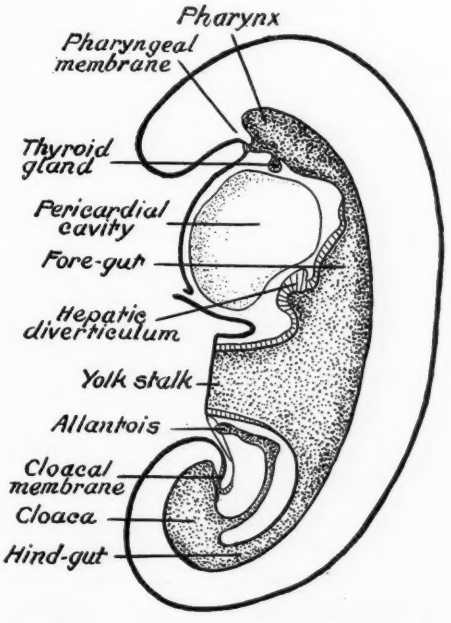

FIG. 215.—Extent and relations of the primitive entodermal tract shown by stereograms of the right half of human embryos at 2·5 mm. (× 30.) (*After Thompson — from Arey's 'Developmental Anatomy'.*)

walls and the post-anal gut into the posterior wall. The cloacal membrane extends from the umbilicus to the base of the tail, and thus is of considerable length but is narrow from side to side. The primitive entodermal gut extends

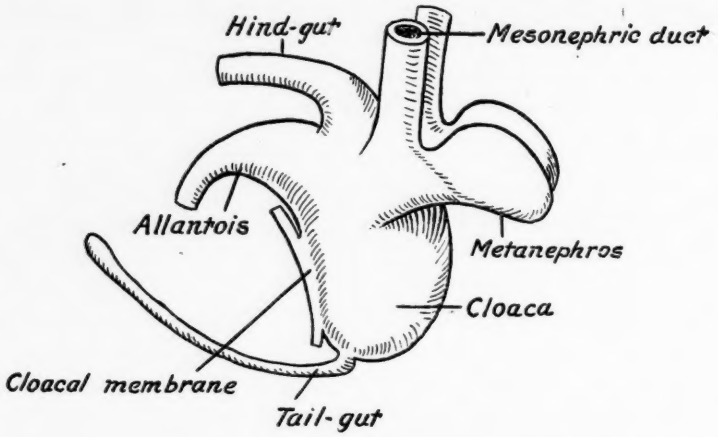

FIG. 216.—Reconstructions of the human cloaca, viewed from the left side, during the earlier period of its division at 5 mm. (× 40.) (*After Pohlman—from Arey's 'Developmental Anatomy'.*)

for some distance beyond the cloacal membrane and this portion is called the post-anal gut.

In embryos of 5 mm. the cloaca commences to divide into two portions by the development of the urorectal septum, which grows forward from a point between

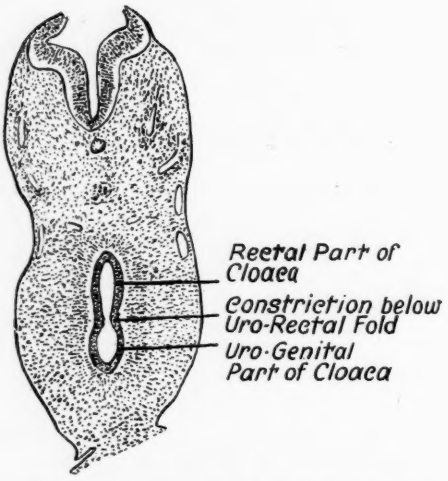

FIG. 217.—Transverse section through cloacal region of human embryo of 9 mm. (× 35.)

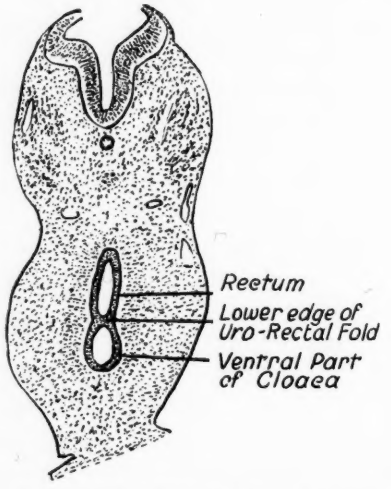

FIG. 218.—Subdivision of cloaca into rectum and urogenital portion in human embryo of 9 mm. (× 35.)

the openings of the hind-gut and allantois until it meets the cloacal membrane, which is bisected into the urogenital and anal membranes (*Figs.* 217, 218). At a stage between 13 and 18 mm. both of these membranes are perforated and the intervening tissue differentiates into the perineum. The end of the hind-gut

(*Figs.* 219, 220) becomes lined with ectoderm for a short distance and this portion constitutes the anal canal. Wood-Jones has pointed out that the recto-vesical

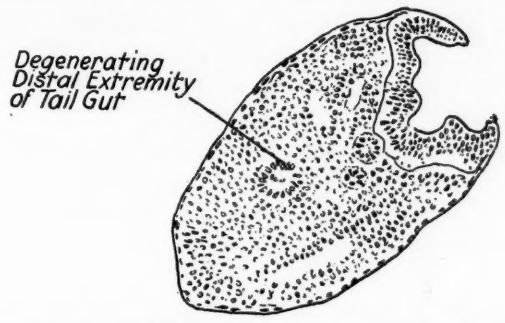

FIG. 219.—Transverse section through the tail end of a human embryo of 9 mm. (× 75.)

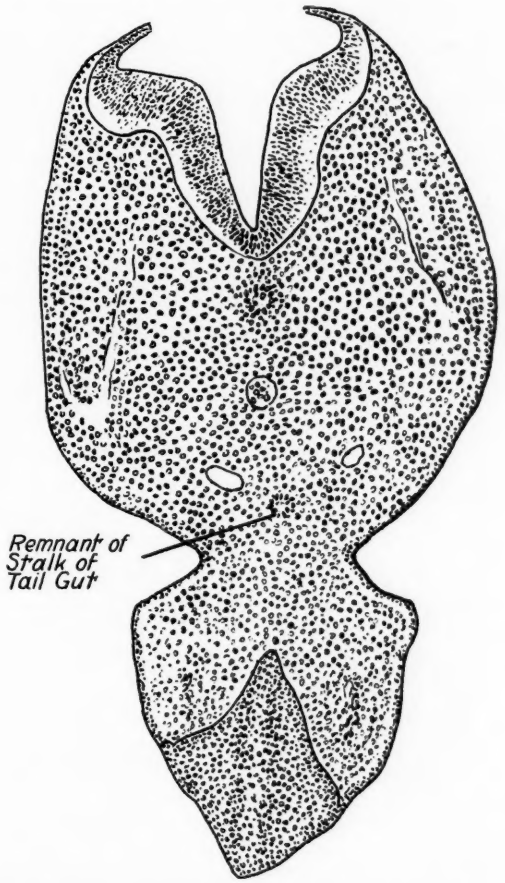

FIG. 220.—Transverse section through the tail end of a human embryo of 9 mm. showing remnant of stalk of tail gut. (× 75.)

pouch corresponds roughly to the site of junction of the hind-gut and cloaca. The reflection of peritoneum from the anterior surface of the rectum marks the site of the former cloacal opening of the hind-gut.

Relation of the Primitive Streak.—In the invertebrate there is a circular opening in the gastrula-cavity called the blastopore. In forms higher than Amphibia the blastopore is replaced by the primitive streak, and these structures are thought to be homologous. In the later stages of gastrulation a sheet of mesoderm

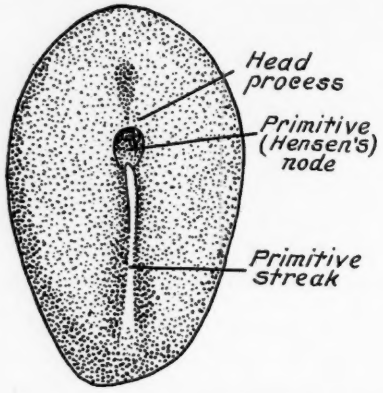

FIG. 221.—Blastoderm of rabbit embryo. (*After van Beneden—from Jordan and Kindred's 'Embryology'.*)

appears between the ectoderm and the unfolding entoderm and an oval plate is formed. In the mid-line of this oval mesodermal plate fusion occurs between the mesoderm and overlying ectoderm, and underlying entoderm. This

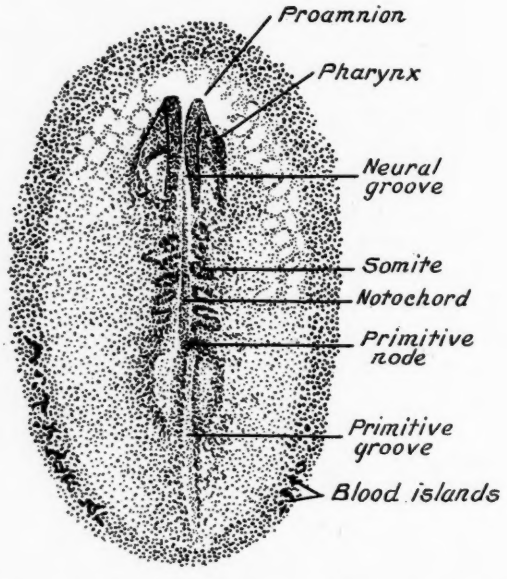

FIG. 222.—Chick embryo of 25 hours' incubation. (*A. Gurwitsch—from Jordan and Kindred's 'Embryology'.*)

line of fusion of three germinal layers is the primitive streak. Experimental evidence adduces that the major portion of the body is developed from the primitive streak. The embryo arises in the neighbourhood of the anterior end and the anus is formed at the posterior end. (*Figs.* 221, 222.)

Constituents of the Primitive Streak.—In the mid-line of the primitive streak is the primitive groove bounded laterally by the primitive folds. Caudally, the primitive folds become flattened out to form the primitive plate, whilst at the head end they become confluent and partially enclose the primitive pit. In the floor of the primitive pit a transient opening may develop between the underlying gut and the lumen of the neural tube; this opening is the neurenteric canal. At the anterior aspect of the primitive streak is the primitive node, or Hensen's node. From the primitive node the primordium of the notochord grows forward in the mid-line. At the same time the primitive streak becomes shorter as if its tissues were being converted in part into notochord. Ultimately the primitive streak appears as a minute remnant to be incorporated in the tail bud.

PATHOLOGICAL STRUCTURES ON THE POSTERIOR ASPECT OF THE SACRUM AND COCCYX

Brief reference is made to certain cysts and sinuses which are encountered on the posterior aspect of the sacrum and coccyx. It is important to recognize the pathology of these abnormalities in order to institute the appropriate surgical treatment. The commonest lesion of this type is termed 'pilonidal sinus', or sacro-coccygeal fistula. Bland-Sutton regarded the cause as faulty coalescence of the cutaneous covering of the back and compared the lesion with the interdigital pouch of the sheep. Newell states that the condition is a dermoid caused by traction of the underlying tissues on the median raphé when retrogression of the tail commences. The lesion presents an orifice 3 to 5 mm. in diameter in the posterior mid-line of the body at about the level of the sacro-coccygeal joint. Occasionally a small tuft of hair may be seen projecting from the orifice. The sinus passes in an upward direction for a variable distance towards the sacrum and terminates blindly without communicating with other structures. Histological examination of the sinus wall shows a lining of squamous epithelium, and therefore the appropriate treatment is complete surgical excision.

Miles has called attention to another type of fistula which results from a hæmatoma caused by a fall upon the buttocks. The aperture in these cases is almost invariably situated on the left side within half an inch of the upper extremity of the internatal cleft. Schmidt has described a sacral dermoid with several fistulous openings associated with a complex mesodermal tumour containing tubules lined by cylindrical cells. Mallory has described a glioma occurring in this region which he believed originated in the remains of the neural canal.

PATHOLOGICAL STRUCTURES ON THE ANTERIOR ASPECT OF THE SACRUM AND COCCYX

These may be classified as: (*I*) *Cysts*; (*II*) *Tumours*. They are dealt with in detail below.

I. CYSTS

1. Dermoid Cysts

Dermoid cysts are composed essentially of derivatives of the ectodermal layer and commonly originate by the inclusion of a portion of ectoderm during coalescence of cutaneous surfaces or at the union of ectodermal with other structures. They

also occur along the course of ectodermal invaginations and from the persistence of embryological ectodermal structures. Dermoid cysts may be simple or complex. In the former the lining is columnar or squamous epithelium with or without skin appendages. In the complex variety various structures such as teeth are present.

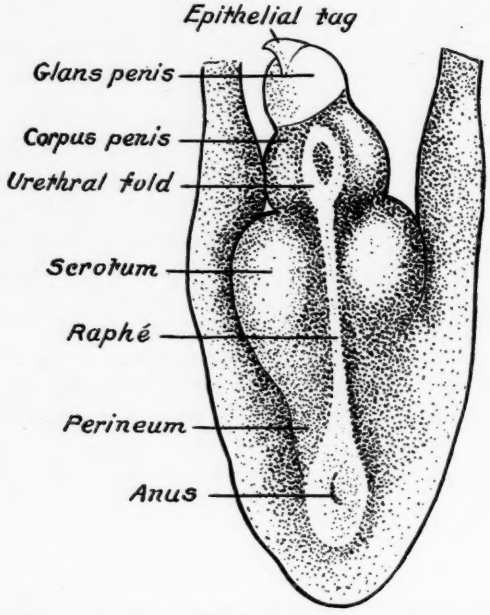

FIG. 223.—The development of the external genitalia of the human male at 12 weeks. (× 6.)
(*After Spaulding—from Arey's 'Developmental Anatomy'.*)

Skutsch has collected from the literature the records of seventeen cases of dermoid occurring in the pelvic connective tissue. The commonest site is between the rectum and sacrum, and the tumour may expand laterally or in a vertical direction. In some cases they are found on the lateral aspect of the rectum and in the ischiorectal fossa. Two cases were found to have cysts in the gluteal region.

FIG. 224.—*Case* 1. Dermoid cyst arising from the perineum. (*Natural size.*) (*R.C.S. Museum*, 1199.1.)

Examples of Dermoid Cysts in the Region of the Rectum.—

1. *Arising from an Ectodermal Inclusion during Coalescence of Cutaneous Surfaces* (*Fig.* 223).—The following case is an example of this type :—

Case 1.—**Dermoid cyst from the perineum** (*R.C.S. Museum*, 1199.1).

HISTORY.—A bi-lobed cyst excised from the perineum near the perineo-scrotal junction of a male aged 13 years.

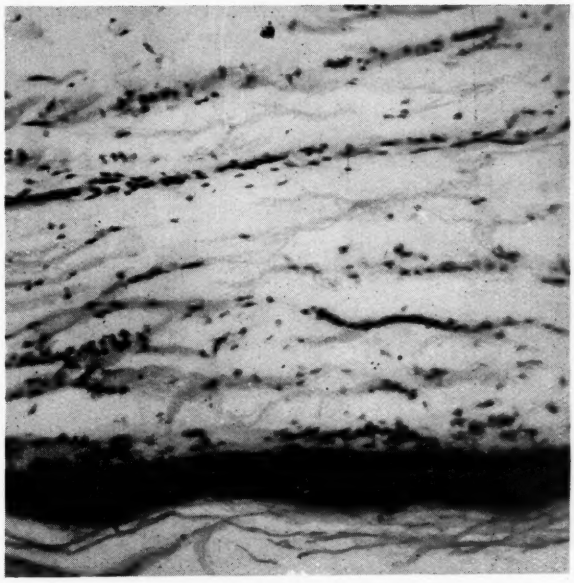

FIG. 225.—*Case* 1. Microscopic section of dermoid cyst from perineum. The cyst is lined with epidermis furnished with a stratum granulosum. (× 240.)

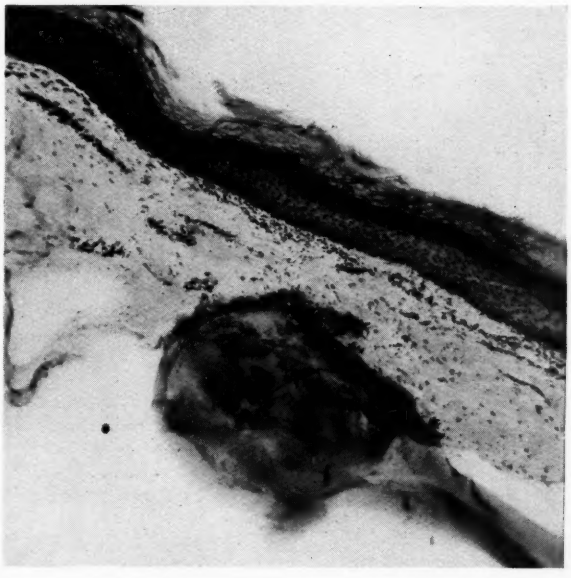

FIG. 226.—*Case* 2. Microscopic section of dermoid cyst from ischiorectal fossa. Wall of cyst lined with squamous stratified epithelium showing a well-marked stratum granulosum as in the epidermis. (× 75.)

NAKED-EYE DESCRIPTION.—A cyst composed of two loculi which communicate through a narrow channel (*Fig* 224). The cyst has a tubular pedicle about 2 cm. in length, which opened in front of the anus.

MICROSCOPICAL STRUCTURE (*Fig.* 225).—The cyst is lined with epidermis furnished with a stratum granulosum. The pedicle is also lined with well-developed epidermis showing papillæ. No hair follicles or glands are present.

2. *Arising in connection with the Proctodeum.*—An example of this type is given below :—

Case 2.—**Dermoid cyst from the ischiorectal fossa** (*R.C.S. Museum*, 1200.1).

HISTORY.—Cyst removed from the ischiorectal fossa of a boy in close proximity to the rectum.

NAKED-EYE DESCRIPTION.—A small spherical thin-walled cyst, 2·5 cm. in diameter. It was filled with desquamated epithelial cells.

MICROSCOPICAL STRUCTURE (*Fig.* 226).—The cyst is lined with squamous stratified epithelium showing a well-marked stratum granulosum as in the epidermis. Immediately beneath the epithelial lining are sparsely scattered, very obliquely disposed hair follicles.

FIG. 227.—*Case* 3. Sagittal section through the pelvis showing a cyst arising from the sacro-coccygeal region. (× ⅛.) (*Museum of St. Bartholomew's Hospital*, L278.)

3. *Arising from the Neurenteric Canal.*—An example of a cyst arising in the sacro-coccygeal region is given below.

Case 3.—**Cyst from the sacro-coccygeal region** (*Museum of St. Bartholomew's Hospital*, L278).

HISTORY.—The pelvic organs of a child, aged 2 weeks, who died as a result of intestinal obstruction caused by a bluish-red fluctuating swelling protruding at the anus.

NAKED-EYE DESCRIPTION.—A sagittal section through the pelvis of a child showing a large cyst below the rectum, situated in front of the sacrum and coccyx and bulging into the anus (*Fig.* 227). There is marked narrowing of the lumen of the rectum, which has been

laid open to show the obstruction. The cyst was filled with clear fluid. The large intestine was much distended and there was a small perforation in the cæcum; fæcal matter had passed into the peritoneal cavity.

MICROSCOPICAL STRUCTURE.—The cyst is lined with a single layer of flattened epithelium.

Galletly believes that simple pre-sacral cysts lined by squamous or columnar epithelium probably originate from cells of the neurenteric canal, which is an ectodermal invagination connecting the neural tube with the primitive hind-gut. He describes a cyst removed from the pelvis of a female aged 43 years. Microscopical examination showed a lining of squamous epithelium with areas of keratinization, and intracystic tufts composed of tubules lined by columnar cells of intestinal type.

Complex Dermoid Cysts in the Region of the Rectum.—Complex dermoid cysts are not common in the sacro-coccygeal region and are usually noticed before puberty. The following examples are therefore of interest:—

Case 4.—**Complex dermoid cyst** (*Museum of St. Bartholomew's Hospital*, L277).

HISTORY.—Cyst removed from a female, aged 39 years, who had experienced some inconvenience in assuming the sitting posture. On the occasion of her confinement the

FIG. 228.—*Case* 4. Complex dermoid cyst containing hair and teeth. ($\times \frac{4}{5}$.) (*Museum of St. Bartholomew's Hospital*, L277.)

head in its descent extruded the cyst through the anal orifice. The cyst was covered by the mucous membrane of the gut, the rupture of which permitted enucleation of the whole cyst.

NAKED-EYE DESCRIPTION.—A cyst containing two balls of hair (*Fig.* 228). There are two fairly well-formed teeth attached to its wall—one molar and one incisor. The cyst is pear-shaped and was attached by its apex.

Case 5.—**Complex dermoid cyst** (*Museum of Guy's Hospital*, 585).

HISTORY.—Cyst removed from the sacro-coccygeal region.

NAKED-EYE DESCRIPTION—The cyst has been opened and everted to show its cavity lined with skin to which are attached a few downy hairs (*Fig.* 229). There projects into

the cavity a rudimentary limb with three malformed digits, each of which bears a claw-like nail. Under the skin of the cyst there is a layer of fatty areolar tissue in which were embedded numerous pieces of bone.

FIG. 229.—*Case* 5. Complex dermoid cyst containing hair and a rudimentary limb. (× ⅓.) (*Museum of Guy's Hospital*, 585.)

2. CYSTS ARISING FROM THE EMBRYONIC POST-ANAL GUT

It has been shown that the developing anal canal joins the intestinal wall at some distance from the extremity of the intestine. Consequently a portion of the distal region of the intestine lying on the ventral surface of the coccyx is cut off from the intestinal canal and becomes atrophic. Attention was first directed to the pathology of the post-anal gut by Middeldorpf. He described a cystic tumour removed from a child of 1 year. The specimen was composed of fat, connective tissue, with layers of intestinal mucosa and mucous glands. Middledorpf was of the opinion that the cyst was derived from the post-anal gut, and this view concerning the origin of certain cysts and tumours has been supported by Keen and Bland-Sutton. Such cysts may be analogous to Meckel's diverticulum and to certain varieties of œsophageal diverticula encountered in the region of the bifurcation of the trachea.

The anatomical position of a derivative of the post-anal gut is on the posterior aspect of the rectum and anterior to the sacrum and coccyx. These cysts are lined with columnar epithelium, which in parts may be ciliated. Mucous glands of intestinal type may also be present.

Case 6.—**Cyst derived from the post-anal gut** (*Museum of St. Bartholomew's Hospital*, TE165).

HISTORY.—An infant of 2½ months was admitted to hospital with acute intestinal obstruction, and an exploratory laparotomy was performed. The child died during the following day.

NAKED-EYE DESCRIPTION.—The specimen shows the pelvic organs together with the kidneys and ureters of a female infant (*Fig.* 230). An oval cyst, 5 cm. in its long diameter,

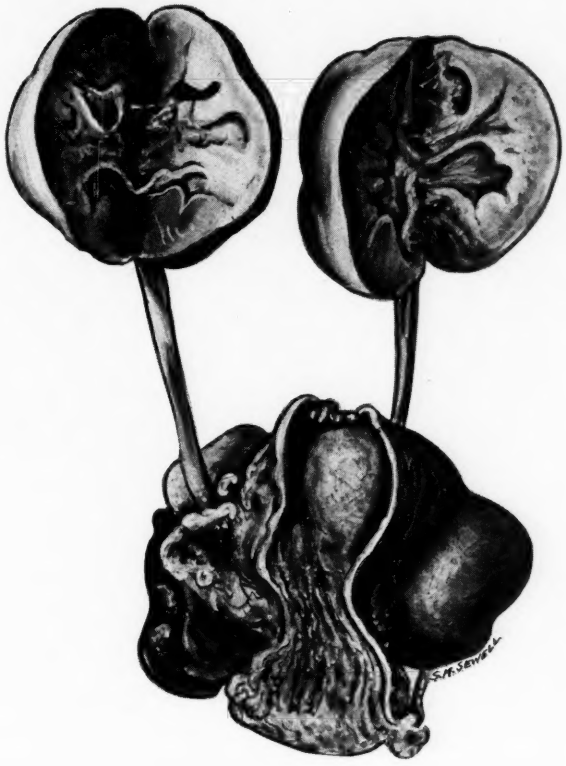

FIG. 230.—*Case* 6. Pelvic organs with kidneys and ureters of a female infant. (× ⅔.) (*Museum of St. Bartholomew's Hospital, TE*165.)

is attached to the posterior wall of the rectum. The cyst has been laid open to show the thickness of its walls. A small fibrous cord joins the lower part of the cyst to the posterior margin of the anus. The ureters and pelves of the kidneys are dilated owing to pressure of the cyst in the pelvis.

MICROSCOPICAL STRUCTURE.—The cyst is lined by several layers of cells, the innermost of which is columnar and ciliated.

3. SACRO-COCCYGEAL CYSTS OF MENINGEAL ORIGIN

The following is an example of this variety of cyst:—

Case 7.—**Sacro-coccygeal cyst of meningeal origin.**

HISTORY.—Specimen removed from a post-mortem subject, death occurring from other cause. This was investigated by kind permission of Professor G. Hadfield.

NAKED-EYE DESCRIPTION.—The specimen (*Fig.* 231) shows the sacrum and coccyx. The first sacral foramina are abnormally large and permit the passage of two large cysts

derived from the meninges of the spinal cord. The larger cyst on the right side is traversed by several nerves.

MICROSCOPICAL STRUCTURE.—The cysts are lined by flattened cells. A small piece of bone is present in the wall of the larger cyst.

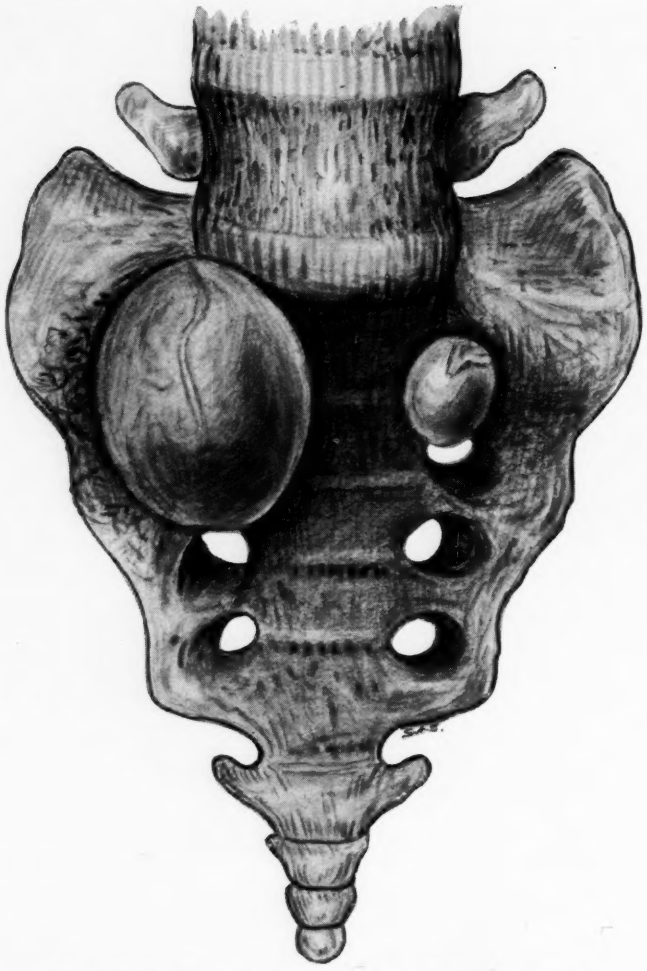

FIG. 231.—*Case* 7. Sacro-coccygeal cyst of meningeal origin.

II. TUMOURS

A survey of the literature shows what a diversity of tumours have been found in the sacro-coccygeal region. Practically all types of tumours are represented here. They may be divided as follows :—

SACRO-COCCYGEAL TUMOURS

1. Innocent
   - *a*. Lipoma
   - *b*. Fibroma
   - *c*. Myoma
   - *d*. Chondroma
2. Glioma derived from ependymal cells
3. Neuroblastoma
4. Chordoma
5. Tumours associated with spina bifida
6. Teratoid tumour
7. Teratoma
8. Parasitic fœtus
9. Sarcoma
10. Carcinoma
11. Endothelioma

It is important that sacro-coccygeal tumours be considered in the differential diagnosis of other swellings occurring in the pelvis, such as fibroid tumours of the uterus, cysts of the ovary, tubal and abdominal pregnancy, pelvic abscesses, intraligamentous cysts, and anterior spina bifida.

Teratomata

This type of tumour appears to be the commonest variety occurring in the sacro-coccygeal region. As in the case of teratoma in general, there are numerous hypotheses held concerning their genesis. In an excellent paper Nicholson has drawn attention to the possibility of tumour formation being the expression of an inherent and physiological reaction of the individual. He states that tumours are pathological manifestations of physiological growth. The activities of a tumour are always reducible to the physiological reactions which underlie somatic growth in spite of their erratic and autonomous nature. The solution to the problem of tumour formation will probably not come until more precise knowledge is available concerning physiological growth. In this connection important contacts are being made between pathology, physiology, and the developing science of experimental embryology. One cannot escape being impressed with the importance of the discoveries in this new field which is being prospected and opened up—discoveries that are concisely set out in a recent publication by Huxley and De Beer.

The Nature of Teratomata.—Until recent years our knowledge of the nature of teratomata has been very poor. Light has been thrown on the problem by Budde (1921), Nicholson (1929), and Willis (1935).

Homology with Distorted Fœtus.—It has been said that a teratoma is really a distorted fœtus. Recent opinion holds that this view is untenable. An embryo is a viable and independent individual, whereas a teratoma is a part of the body of its host. Willis points out that in a teratoma the fundamental features of the formation of a soma are not present—that is, there is no evidence in the tumour of axiation, metameric segmentation, or delamination of germ layers. There is no topographical arrangement of tissues in a teratoma such as is seen in the fœtus; there are numerous intestinal cysts, but no real alimentary canal can be found; there is abundance of nervous tissue, but no well-developed brain is present; masses of bone may be seen, but no named bone can be identified.

If the view is accepted that a teratoma does not represent a distorted fœtus, the two further hypotheses must automatically be rejected—of twin-inclusion and parthenogenesis. Imperfect twins and parthenogenic organisms do not reveal the absence of axiation and segmentation which is seen in most teratomata.

Tissue Correlations in Teratomata.—This subject has been admirably worked out recently by Nicholson and Willis. In these tumours is demonstrated the physiological stimulus which is exerted by one tissue on another.

Tooth Formation in Teratomata.—Tooth formation in these tumours shows a sequence of correlations similar to those of normal ontogeny. The invaginated enamel organs stimulate the formation of dental papillæ in the mesenchyme from which develops odontoblastic tissue and pulp. Bone may even be formed around these developing teeth, and structures like the maxilla may be formed.

Respiratory Epithelium and Cartilage.—It is very probable that respiratory epithelium stimulates surrounding mesenchyme and this reacts to the physiological stimulus with the production of cartilage.

Glandular Epithelium and Smooth Muscle.—When smooth muscle is present in teratomata it is generally associated with glandular acini. Willis states it appears that particular kinds of epithelia growing amongst indifferent mesenchyme induces the latter to form muscle, and he describes the genesis and growth of these organoid

FIG. 232.—*Case* 8. Sacro-coccygeal teratoma. (× ⅛.) (*R.C.S. Museum*, 1549.1.)

formations through all stages. He pertinently expresses a suspicion that the same inductive influence of epithelium is responsible in normal ontogeny for the development of muscle in the walls of the viscera.

Examples of Sacro-coccygeal Teratomata.—The following nine cases are examples of sacro-coccygeal teratomata :—

Case 8.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1549.1).

HISTORY.—Tumour removed from the nates of a child aged 2 years.

NAKED-EYE DESCRIPTION.—An irregular oval tumour partly bisected, 11·5 cm. in its chief diameter (*Fig.* 232). In the upper part a piece of intestine 7·6 cm. in length has been dissected out; this is blind at one end, and originally contained fluid resembling meconium. Above this on the left a few nodules of cartilage are present. On the outer side there is a more or less isolated lobe in which are scattered cystic cavities.

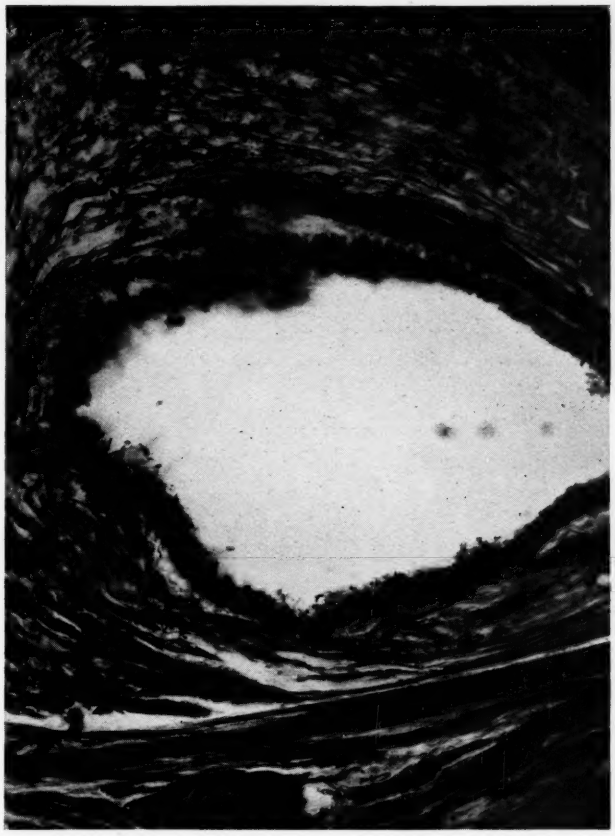

FIG. 233.—*Case* 8. Microscopic section of sacro-coccygeal teratoma. The section shows dense fibrous tissue with a few nerves present with a small amount of smooth muscle fibres. An extensive cleft is shown lined with columnar epithelium but without any proper wall. (× 240.)

MICROSCOPICAL STRUCTURE (*Fig.* 233).—The main mass of tumour consists of dense fibrous tissue intermixed with fat. The isolated lobe on the outer aspect of the tumour consists of fibrous tissue with intervening zones of mucous tissue from which fat is forming. Extensive clefts are present, lined with columnar epithelium but without any proper wall. A few well-formed nerves are present and there is a small amount of smooth muscle fibres.

Case 9.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1550.1).

HISTORY.—Tumour removed from the gluteal region.

NAKED-EYE DESCRIPTION.—The greater part of the tumour consists of a large multilocular smooth-walled cyst at its free end, and of other cysts at its superior extremity (*Fig.* 234). The two larger cysts were filled with fatty material; amongst this were a few short dark hairs. Behind the largest of the upper cysts is a short blind coil of gut. On the posterior aspect of the tumour there are two areas of pigmented skin, and in the centre of the lower area is the orifice of a canal 2·5 cm. in length.

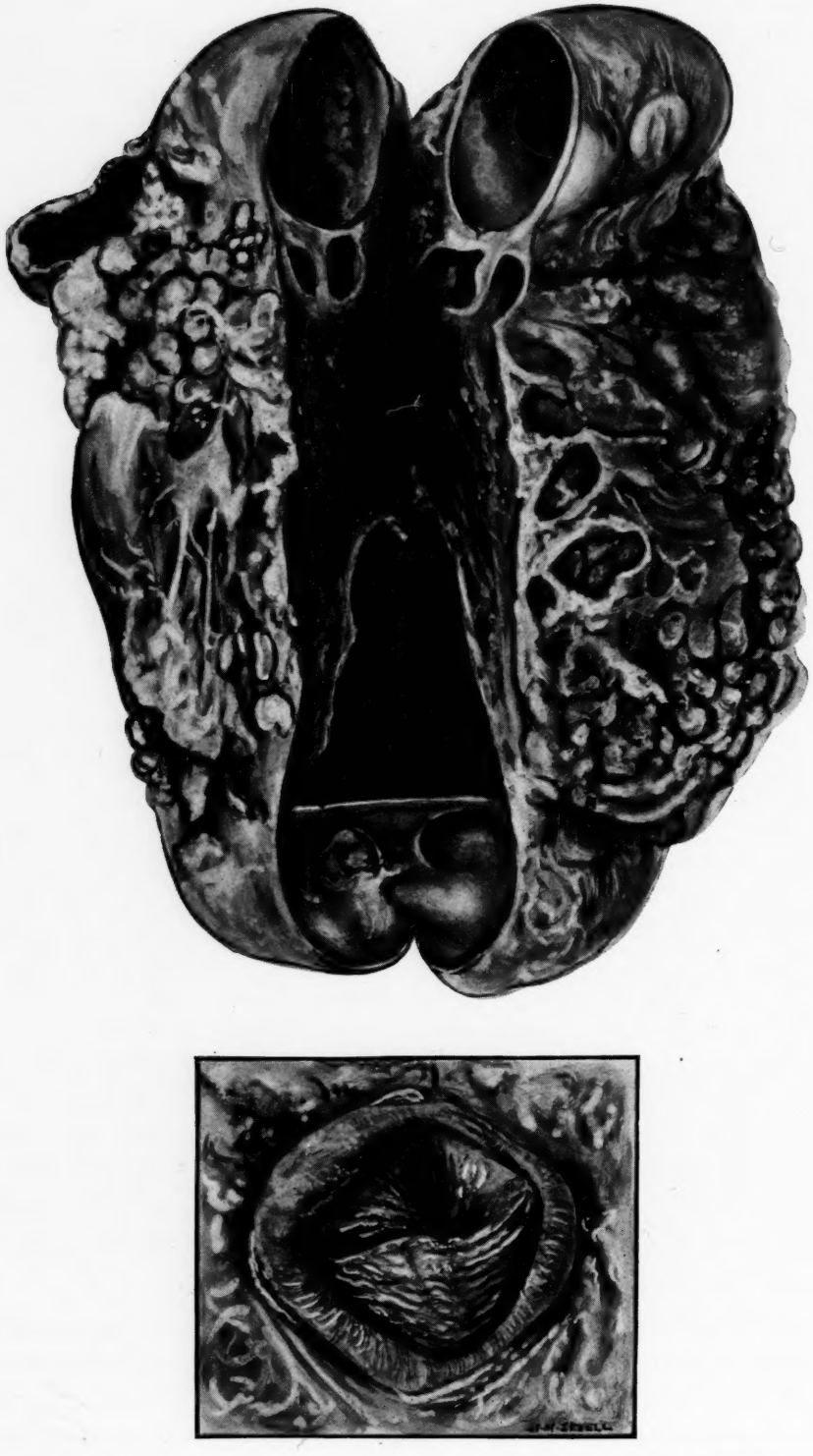

FIG. 234.—*Case* 9. Sacro-coccygeal teratoma. × ½.) (*R.C.S. Museum*, 1550.1.)

MICROSCOPIC STRUCTURE (*Figs.* 235, 236).—The epithelium of the blind coil of gut is glandular and resembles gastric mucosa in parts; other portions show intestinal type of

FIG. 235.—*Case* 10. Microscopic section of sacro-coccygeal teratoma showing epithelium composed of columnar cells resembling that of the large intestine. Numerous goblet cells are visible. (× 240.)

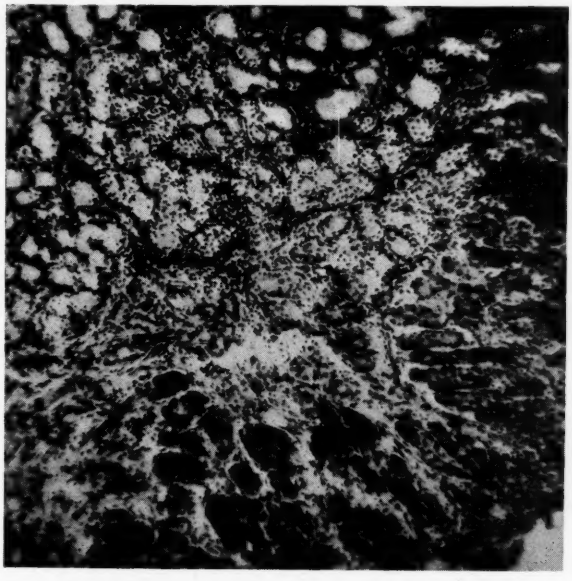

FIG. 236.—*Case* 10. Microscopic section of sacro-coccygeal teratoma showing glandular epithelium resembling gastric mucosa. (× 75.)

epithelium. Beneath this epithelium there are small nodules of bone and cartilage and also a small lymph gland.

Case 10.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1550.2).

HISTORY.—Child born with a large tumour attached to the tip of the coccyx. The anus was rudimentary, and fæces were passed through the vulva.

NAKED-EYE DESCRIPTION.—Half of a bi-lobed tumour measuring 16 cm. in its longest diameter (*Fig.* 237). As displayed, it shows two cysts of about equal size consisting of skin with a thin proper wall adherent to it. A somewhat pedunculated solid growth projects into each cyst. The intracystic growth consists of connective tissue in which lies an abundance

FIG. 237.—*Case* 10. Sacro-coccygeal teratoma. (× $\frac{1}{3}$.) (*R.C.S. Museum*, 1550.2.)

of finely lobulated white fat. In the connective tissue there are embedded a few small islets of cartilage and bone; one of these is indicated in the lower segment of *Fig.* 237 by two black bristles. A certain number of well-defined, thin-walled cysts are distributed in the two tumours, especially about their bases of attachment. One of these cysts contains a few slender dark hairs.

MICROSCOPICAL STRUCTURE.—The main mass of the tumour consists of simple adipose and connective tissue. The cysts are lined with columnar epithelium which is ciliated in parts. Some of these cysts are papilliferous, showing intestinal villi and crypts. In the

fibrous tissue adjoining the crypts are sharply defined areas of neuroglia. Strands of unstriped muscle run in the course of some of the fibrous septa, but without any definite relation to the cystic spaces.

Case 11.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1550.3).

HISTORY.—Tumour removed together with the coccyx from the sacro-coccygeal region of a child aged 2½ years.

NAKED-EYE DESCRIPTION.—The cut section of the tumour shows a preponderance of fat which is closely connected in its deepest part with the coccyx and is covered superficially with normal skin.

MICROSCOPICAL STRUCTURE.—The tumour consists of fat, striped muscle fibres, and nerve bundles.

FIG. 238.—*Case* 12. Sacro-coccygeal teratoma. (× ⅛.) (*R.C.S. Museum*, 1545.1.)

Case 12.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1545.1).

HISTORY.—The infant was born with the tumour, and died at the age of 6 weeks.

NAKED-EYE DESCRIPTION.—The specimen shows the right half of the lower part of the body of an infant (*Fig.* 238). The rectum and lower part of the sacrum and coccyx are widely separated by a large oval tumour 14 cm. in its chief vertical diameter. The tumour

is everywhere sharply circumscribed and is minutely cystic throughout. It is imperfectly subdivided into lobes by strands of connective tissue.

MICROSCOPICAL STRUCTURE.—The tumour is composed of spaces lined with cubical or columnar epithelium. In the intercystic partitions branching plates of hyaline cartilage are present which have undergone ossification in places.

Case 13.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1546.1).

HISTORY.—A female infant was born with a large sacro-coccygeal tumour. The specimen was obtained when the child was aged 3 months.

NAKED-EYE DESCRIPTION.—One half of a vertical section of a large congenital sacro-coccygeal tumour. A portion of the tumour projected backwards behind the apex of the coccyx. The coccyx is displaced posteriorly. The tumour is imperfectly divided into lobes of considerable size, all of which are finely spongy or more coarsely cystic. In the recent state the spaces contained a glairy transparent fluid.

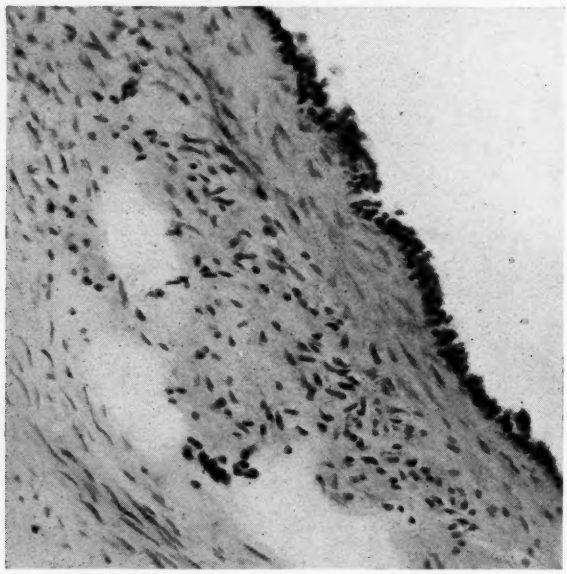

FIG. 239.—*Case* 13. Microscopic section of sacro-coccygeal teratoma. Lining of cystic space composed of columnar epithelium. The stroma is very cellular. (× 240.)

MICROSCOPICAL STRUCTURE (*Fig.* 239).—The complex structures are lined with columnar epithelium. The stroma is fairly abundant and very cellular; in parts it is mucous and contains groups of fat cells. There are small well-defined areas of hyaline cartilage sparsely distributed in the stroma.

Case 14.—**Sacro-coccygeal teratoma** (*R.C.S. Museum*, 1838.1).

HISTORY.—A premature child born with a sacro-coccygeal tumour.

NAKED-EYE DESCRIPTION.—A sagittal section of the lower part of the trunk of a premature child (*Fig.* 240). Between the sacrum and coccyx and the rectum there is an ovoid tumour, 7·5 cm. in chief vertical diameter. The tumour is intimately connected with the skin and is of particularly soft consistence though supported by somewhat coarse processes of connective tissue. It contains a few well-defined cysts, certain of which appear to have ruptured on the posterior surface, and has led to the production of external depressions. Immediately on the hinder wall of the rectum, below its middle, there is a small, minutely cystic area of glandular character; similar areas may be found towards the posterior border of the tumour.

MICROSCOPICAL STRUCTURE (*Fig.* 241).—Cystic areas are present which are lined with columnar epithelium. These cysts are dilated to form channels. The stroma contains

nervous tissue in which large branching nerve cells are distributed. A few small well-defined processes of hyaline cartilage occur in the midst of the supporting tissue. Between the glandular elements are small groups and lines of fat cells.

FIG. 240.—*Case* 14. Sacro-coccygeal teratoma. (× ⅛.) (*R.C.S. Museum*, 1838.1.)

FIG. 241.—*Case* 14. Microscopic section of sacro-coccygeal teratoma showing well-defined processes of hyaline cartilage in the midst of supporting connective tissue. (× 75.)

FIG. 242.—*Case* 15. Sacro-coccygeal teratoma. (× ⅛.) (*Museum of Guy's Hospital*, 5857.1.)

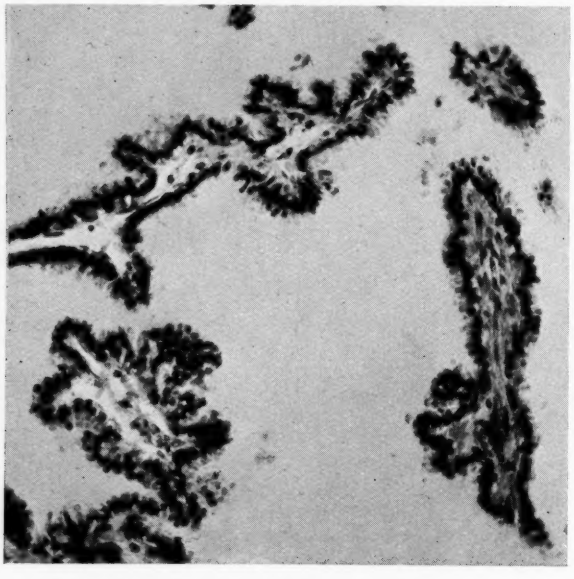

FIG. 243.—*Case* 15. Microscopic section of sacro-coccygeal teratoma showing papillary processes covered with columnar epithelium. (× 240.)

Case 15. **Sacro-coccygeal teratoma** (*Museum of Guy's Hospital*, 5857.1).
HISTORY.—A full-term child born with a sacro-coccygeal tumour.
NAKED-EYE DESCRIPTION.—A sagittal section through the pelvis of a full-term child

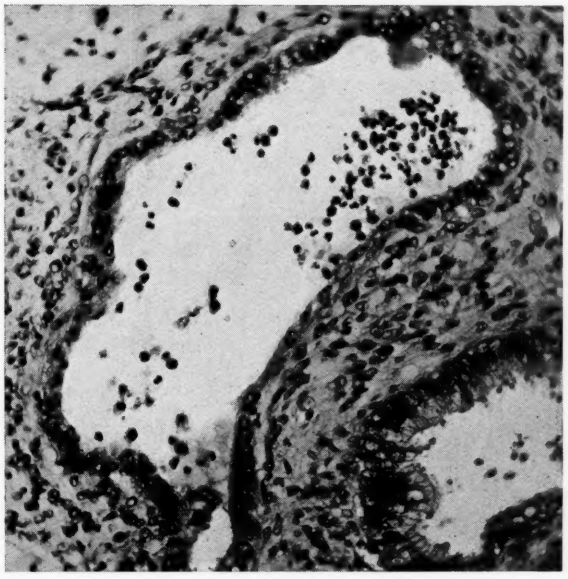

FIG. 244.—*Case* 15. Microscopic section of sacro-coccygeal teratoma showing cystic spaces lined with single layer of columnar epithelium. (× 240.)

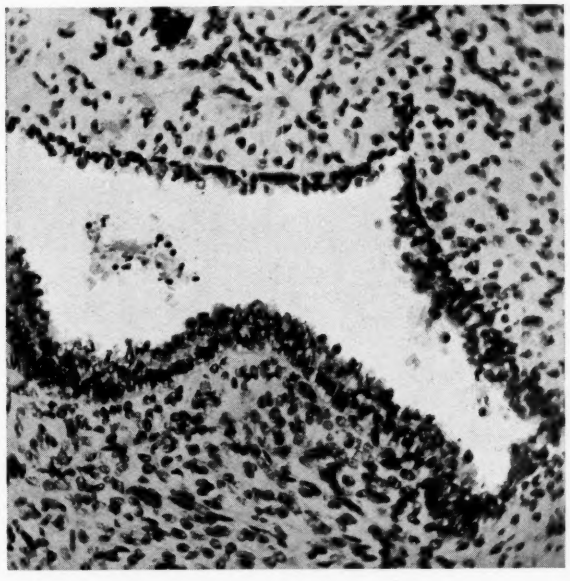

FIG. 245.—*Case* 15. Microscopic section of sacro-coccygeal teratoma showing large cystic cavity lined with columnar epithelium which is several layers thick in parts. (× 240.)

(*Fig.* 242). The anus is displaced forward by a globular tumour 10 cm. in diameter lying between the coccyx and anus and projecting from the perineum. The rectum is stretched over the upper aspect of the tumour, and the rest of its surface is covered by perineal skin

which is œdematous in its lowest part. The tumour is strictly encapsuled and but loosely attached to the surrounding structures. The consistency is soft and the cut surface is beset with numerous small cysts.

MICROSCOPICAL STRUCTURE (*Figs.* 243–245).—Numerous cystic spaces are seen lined by three different types of columnar epithelium. The matrix is composed of loose fibrillary tissue in which are numerous masses of hyaline cartilage.

Case 16.—**Malignant sacro-coccygeal teratoma** (*Museum of St. Bartholomew's Hospital,* L276A).

FIG. 246.—*Case* 16. Malignant sacro-coccygeal teratoma. (× $\frac{1}{5}$.) (*Museum of St. Bartholomew's Hospital,* L276A.)

HISTORY.—The child was aged 2 years and apparently well until five weeks before death, when it was noticed that a bluish swelling had developed on the left buttock. The patient had been constipated. On admission to hospital a firm elastic swelling was found situated on the left side of the anus, and the urinary bladder was distended. The swelling was incised and about 2 oz. of blood-clot and degenerated tissue were evacuated.

NAKED-EYE DESCRIPTION.—A sagittal section through the pelvis of a child showing a friable tumour situated between the sacrum and rectum (*Fig.* 246). It extends upwards to

the level of the fifth lumbar vertebra. Inferiorly it causes a swelling in the left buttock where an incision has been made. The lower segments of the sacrum and coccyx are eroded and the rectum is pushed forward. The urethra is elongated and the bladder displaced upwards. The lower part of the tumour is hæmorrhagic, the middle is brown in colour, and the upper part is paler. There are a number of small cystic spaces present.

MICROSCOPICAL STRUCTURE.—The tumour consists chiefly of irregular cells with pale cytoplasm, and the nuclei show mitotic figures. There is an attempt on the part of the cells to form alveoli. Interspersed amongst the cellular elements are plain muscle fibres.

In the present state of our knowledge of tumours in general and of teratomata in particular, it is impossible to state the origin of sacro-coccygeal teratomata. It appears true, as Nicholson suggests, that they are malformations. Further knowledge of their origin will be gained as experimental embryology unravels the intricacies of the complex developmental processes and throws new light on the growth centres of the body situated at the caudal extremity. It may be that these malformations will prove to be due to a faulty coherence of embryonal parts and a diminution of growth momentum.

I gratefully acknowledge the help of Dr. R. J. Gladstone and the curators of many hospital museums for permission to study the pathological material on which this paper is based.

PYLEPHLEBITIS COMPLICATING APPENDICITIS AND ITS TREATMENT BY LIGATURE OF THE MESENTERIC VEINS

By A. M. STEWART-WALLACE

MEDICAL FIRST ASSISTANT AND REGISTRAR, LONDON HOSPITAL

THE following case is reported by kind permission of Mr. Julian Taylor :—

An unmarried girl, age 18, was admitted on March 1, 1932, into University College Hospital with a three days' history of abdominal pain and vomiting, and having obvious signs of general peritonitis.

FIRST OPERATION.—By Mr. Julian Taylor under open ether anæsthesia. Battle's incision. Pus was present in the general peritoneal cavity and welled up out of the pelvis (grew *B. coli* and non-hæmolytic streptococci). The appendix was gangrenous and perforated. It was found below and posterior to the cæcum and was removed. Large rubber drainage tube into pelvis.

The patient was nursed in Fowler's position: 30 c.c. of antiscarlatinal serum and 30 c.c. of double-strength saline were given intravenously. Rectal salines.

March 4.—The general condition was satisfactory. The drainage tube was removed. There was one slight rigor in the evening.

March 5.—The patient complained of occasional colicky pains in the centre of the abdomen. Two definite rigors occurred. There were no physical signs in the chest or abdomen, and no pus-cells or organisms in the urine.

March 6.—There were frequent attacks of severe colicky abdominal pains, much worse after taking any fluids, including water. Bowels not open, no vomiting. One severe rigor in the afternoon. The patient had a dry furred tongue, rapid pulse, and was sweating profusely. There was no jaundice of skin or conjunctivæ, and the heart and chest were normal. There was tenderness on the right side of the abdomen over an area stretching from the appendicectomy wound to half-way between the umbilicus and the right costal margin. No marked rigidity. The edges of the wound were red and inflamed and the sinus was discharging foul-smelling pus. The lower border of the liver was tender on palpation. P.R., nil abnormal.

The patient was seen by Mr. Julian Taylor, who made a pre-operative diagnosis of ascending mesenteric thrombophlebitis and portal pyæmia, and advised immediate laparotomy.

SECOND OPERATION.—By Mr. Julian Taylor under open ether anæsthesia through a right paramedian incision. The general peritonitis had settled down. The superior mesenteric vein was thrombosed from the extreme radicles supplying the cæcal area to within ¾ in. of its junction with the splenic vein. The vein was hard, about the size of the little finger, and covered with flakes of lymph. The splenic and portal veins were unaffected. The liver was engorged and swollen. No evidence of infarction of any part of the intestine. The upper part of the superior mesenteric vein was approached through the posterior layer of the transverse mesocolon and exposed, the right colic artery being tied in the process. The superior mesenteric vein was ligatured immediately proximal to the upper limit of the thrombus. Sudden marked engorgement of all the colic veins was at once apparent as the ligature was tightened. The abdomen was closed without drainage. One pint of intravenous saline was given in the theatre. The patient was extremely shocked, but had recovered considerably one hour later after treatment with warmth, raised lower extremities, and injections of camphor and strychnine; 20 c.c. of antistreptococcal serum were given.

SUBSEQUENT PROGRESS.—The general condition had greatly improved on the following day. There were no further rigors and the hepatic enlargement and tenderness gradually

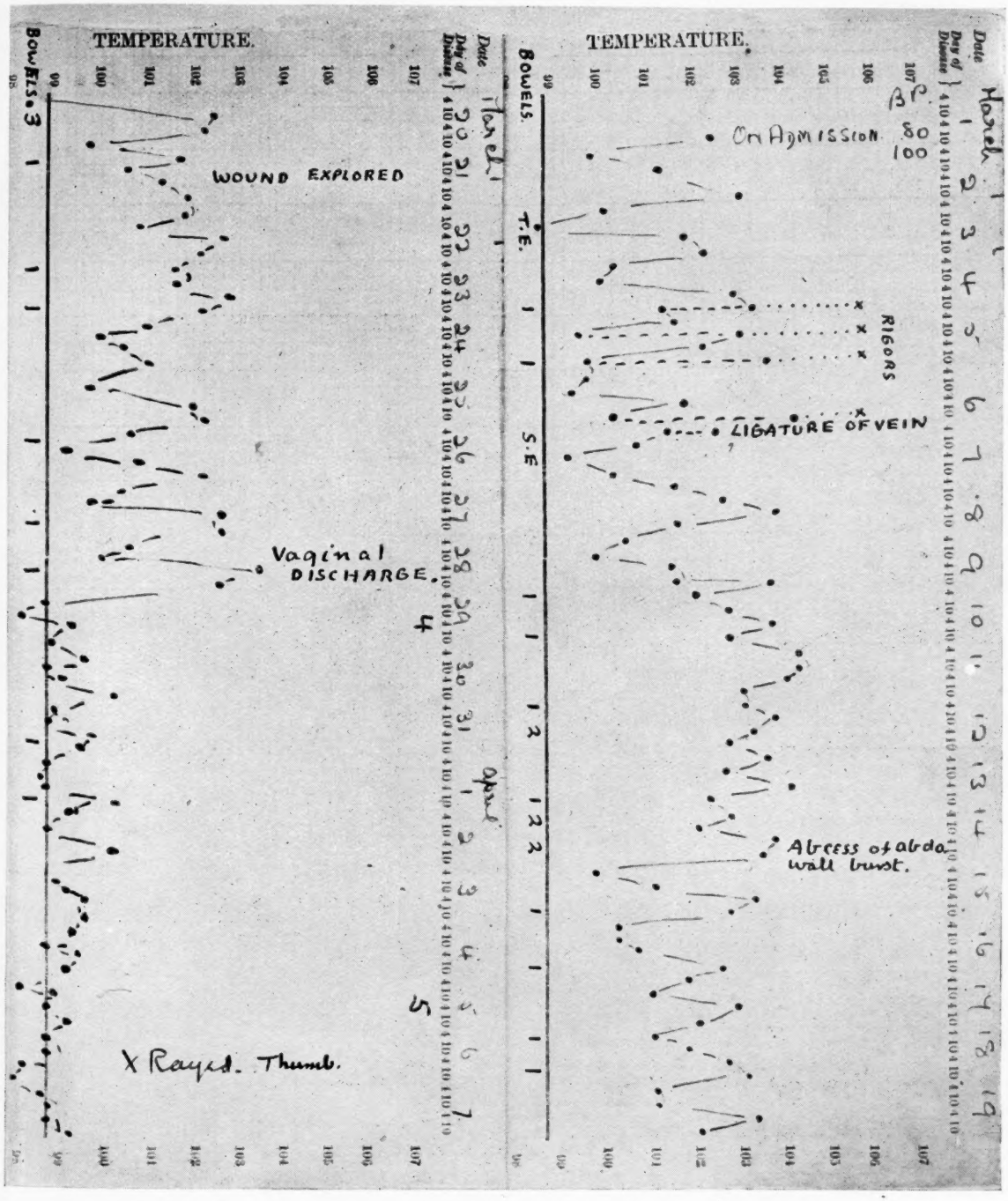

FIG. 247.—Case of post-operative portal pyæmia and ascending pylephlebitis, successfully treated by ligature of the superior mesenteric vein.

subsided. No gross intestinal disturbances were apparent. The colicky abdominal pains of which she had previously complained continued during the next two or three days. A normal result followed an enema on the first day, but thereafter the bowels opened normally; the motions were of normal colour, never loose, and did not contain visible blood.

Her convalescence was complicated by development of pus between the layers of the anterior abdominal wall and a pelvic abscess which finally burst into the vagina. Rapid and complete recovery then followed (*Fig.* 247), and she was discharged on April 26 very fit, free of symptoms, and with her abdominal wounds completely healed. She later returned to work, and during the last three years has remained very well except for occasional slight dyspepsia and mild constipation.

EFFECTS OF OCCLUSION OF THE MESENTERIC VEINS

From experimental ligations on animals it would appear that ligature of the most proximal part of the trunk of the superior mesenteric vein usually produces necrosis of the whole small intestine from the middle of the duodenum to the cæcum; tying the large and medium-sized tributaries, except in large numbers,

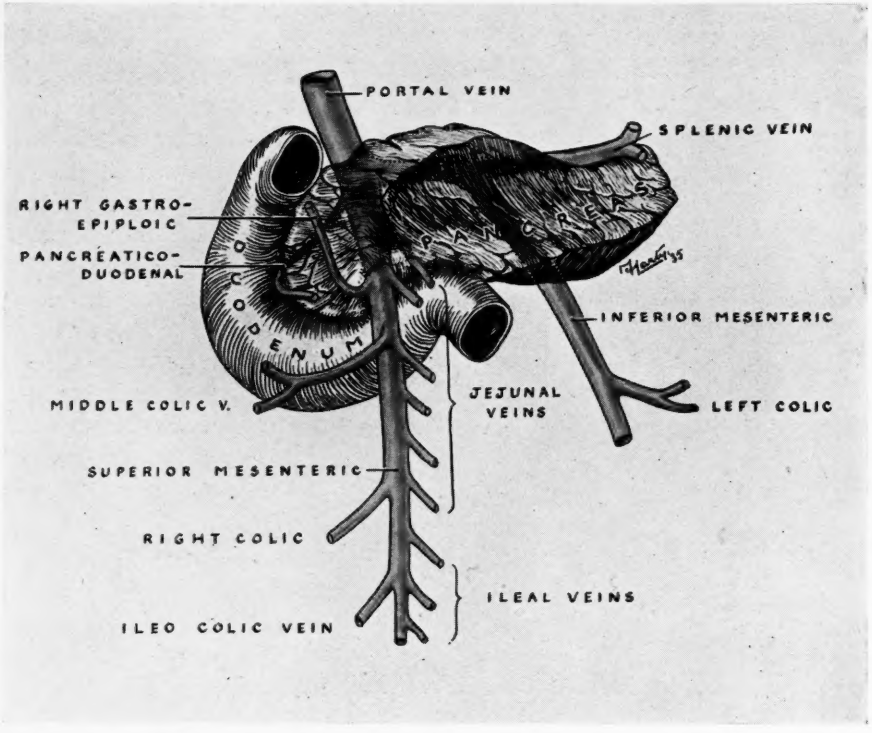

FIG. 248.—The tributaries of the superior mesenteric vein as they are commonly found; the exact arrangement is subject to variation in different individuals.

rarely leads to gross intestinal lesions; while in the case of small radicles in the mesentery close to its line of attachment to the intestine, necrosis usually occurs.

L. B. Trotter found that of 103 cases of superior mesenteric vein thrombosis in man, in which the main trunk was involved, infarction occurred in 70 (68 per cent); and of 34 cases when tributaries only were affected, in 21 (63 per cent) there was infarction. When infarction did not take place the changes found were

œdema, engorgement, hæmorrhage, and ulceration, and, in some slight cases, no intestinal lesion. Though it is not stated precisely to what degree the trunk was involved or how far proximal the thrombus extended, these findings show that the circulation can be carried on even if a large part of the mesenteric venous system has undergone thrombosis. No intestinal infarction occurs so

FIG. 249.—The superior mesenteric vein and its tributaries draining the appendix area, showing the ileocolic vein isolated prelimary to passing a ligature. (*See* p. 372.)

long as the anastomotic arcades and their radicles remain free and some tributaries opening into the vein above the clot are patent. The most extensive thrombosis only leads to lesions confined to a small region of the bowel, that sector in which the thrombosis has spread to involve the anastomotic arcades and their radicles.

The results of ligature of the superior mesenteric vein in man are interesting. Two cases are on record (Robson, 1897, and Wilms, 1901) of traumatic laceration of the main trunk of the vein at the level of the root of the transverse mesocolon, where ligation was followed by complete recovery. Sudeck, Colp, and Braunig each record a case of ligature of the superior mesenteric vein for post-appendicular thrombophlebitis, and though the latter two died from liver abscesses six weeks later and peritonitis two days later respectively, no intestinal infarction occurred. Including our case, therefore, we have been able to collect six instances of ligature of the superior mesenteric vein in man, and no serious damage to the bowel appears to have resulted. The four which completely recovered have suffered no lasting ill effects and a satisfactory collateral circulation must have been established.

Now in all these cases the ligature was applied in the region of the transverse mesocolon and the third part of the duodenum. Though the exact relations of the ligature to the entrance of the various tributaries in this neighbourhood were not accurately known or stated, and though the precise arrangement of the veins varies in different individuals, it will be seen from *Fig.* 248 that the right gastro-epiploic, the pancreatico-duodenal, some of the upper jejunal veins, and in some or all of the cases the middle colic vein, must have opened into the vein proximal to the ligature. The ligature, therefore, has not been applied strictly to the 'trunk' of the vein corresponding to the fatal animal experimental ligatures mentioned. We can conclude, therefore, that it is possible to tie the superior mesenteric vein at or below the level of the transverse mesocolon and third part of the duodenum. But at a higher level, where it is in relationship with the pancreas, animal experiments suggest that necrosis of the whole small intestine would probably result; care must be taken, therefore, not to injure the vein in carrying out operations on the pancreas.

In our case, as the ligature was tightened all the colic veins were seen to distend, and the venous return from the colon must have taken place by way of the anastomotic channels to the middle colic, and round to the left colic into the inferior mesenteric vein; and from the small intestine by way of the upper jejunal, the pancreatico-duodenal, and right gastro-epiploic veins (*see Figs.* 248, 249).

In none of 21 cases in which the ileocolic vein has been ligatured did intestinal necrosis occur. However, ligature of the small veins in the cæcal angle distal to the anastomotic arcade was not without danger; thus a fæcal fistula followed a case described by Sprengel.

THE EARLY SYMPTOMS OF PORTAL PYÆMIA COMPLICATING TYPHLITIS

The diagnosis of portal pyæmia immediately after its onset is such an essential part of any prophylactic measure against pylephlebitis that a careful study and an appreciation of the significance of the earliest signs are of the greatest importance. The condition will present itself as: (1) An acute abdomen with additional rigors and perhaps evidence of hepatic involvement. The signs of the appendicitis may be obvious, or more frequently are atypical and confused by the pyæmic symptoms. (2) A post-operative complication following laparotomy for appendicitis.

An analysis of the five fatal cases of pylephlebitis (*see* p. 373) and Julian Taylor's case of thrombophlebitis of the superior mesenteric vein and engorged swollen liver, which occurred in the course of 5741 cases of appendicitis admitted into the London and University College Hospitals during the last five years, shows that the ages varied from 17 to 38; 5 were male and 1 was female. Two were operated on within twenty-four hours of the onset of symptoms, and one each on the 2nd, 4th, 9th, and 12th days respectively. Multiple pre-operative rigors and tenderness in the right hypochondrium were present in both the latter two, while in one other a single pre-operative rigor had occurred. It is of interest to note that *Case* 2 was operated on within twenty-four hours and *Case* 6 within twelve hours after the symptoms had begun, as it has been frequently stated, particularly by German writers, that pylephlebitis never occurs if the patient is operated on during the first twenty-four hours. A gangrenous appendix was found in all, two of which had ruptured, producing general peritonitis, and the two with the history of over a week had formed appendix abscesses. A fairly high intermittent pyrexia continued after operation, and in those with pyæmic symptoms previous to admission the rigors continued. In the other cases rigors started on the 2nd, 4th, and 15th day after operation respectively. Death resulted in one case in five days, but all the others lived from three to ten weeks after operation.

Of all the early symptoms that indicated that portal pyæmia was complicating the appendicitis the onset of rigors was undoubtedly the most outstanding feature in every case. Abdominal pain is almost always present according to the literature (Langdon-Brown). It is usually said to be the initial symptom, but it may follow one or two rigors. Beginning of inflammation of the portal vein or its tributaries is marked by the onset of pain. Von Schüppel (1880) believed that from its position the exact portion or factor of the vein affected may be determined. In our case colicky abdominal pains occurred on the morning following the first slight shivering attack. The pain was made worse by taking anything by mouth, even water, and gradually increased in intensity. On the next day examination revealed tenderness spreading up from the appendix region to half-way between the umbilicus and costal margin, the area corresponding to the portions of ileocolic and superior mesenteric veins found affected at laparotomy. Tenderness and enlargement of the liver, particularly the former, is present in most cases, but may not develop till a later stage. The liver edge was palpable and tender on the second day after the onset of rigors in Taylor's case, and also on admission in both the cases which had pre-operative pyæmic symptoms. Jaundice is present in less than 50 per cent of cases and often appears late (Lett); it was present in only one of our cases, being first noticed on the fifteenth day. One or more intestinal symptoms, such as furring of the tongue, nausea, vomiting, diarrhœa, or constipation, are usually present.

During the first two or three days, therefore, the stage at which, for our purposes of prophylactic treatment, it is essential to make the diagnosis, the onset of irregular rigors in a case of appendicitis is the outstanding diagnostic feature, and may, indeed, be the only symptom. This should always at once suggest portal pyæmia. Abdominal pain usually occurs if there is thrombosis of the mesenteric veins. Tenderness in the hypochondrium, a palpable tender liver, and occasionally jaundice, may be present and help to make the diagnosis more certain.

DIFFERENTIAL DIAGNOSIS: THE SIGNIFICANCE OF RIGORS

Since rigors may be the only definite sign at this early stage, it is obviously of the utmost importance to understand the significance of rigors complicating appendicitis. Undoubtedly their incidence used to be greater. Thus in Kelly and Hurdon's *Vermiform Appendix and its Diseases* (1905), it is stated that 50 per cent of cases of appendicitis with abscess formation or peritonitis have rigors, a figure which would certainly not apply to the cases admitted into a general hospital to-day. The earlier operation now practised has probably led to this decrease in their incidence, together with a corresponding decrease in the occurrence of pylephlebitis. Langdon-Brown found pylephlebitis in 6 per cent of 42 necropsies on typhlitis in St. Bartholomew's Hospital in the years 1893–8, as opposed to 2·6 per cent of 187 fatal cases from our series in 1930–4. Colp in 1927, in a series of 2841 cases of appendicitis at Mt. Sinai Hospital, New York, in which the presence or absence of chills had been specifically inquired for at the time of taking the histories, found pre-operative rigors in 6·8 per cent, the percentage being the same whatever the severity of the inflammation, whether catarrhal, gangrenous, or with localized or with general peritonitis. The death-rate in those with only one rigor was no higher than in those without, but of those in which two or more occurred, of which there were 11 cases (0·39 per cent), 5 died, 4 from pylephlebitis. Moreover, 88 per cent of the cases which developed pylephlebitis gave a history of pre-operative rigors. It appears, therefore, that one rigor before operation is of little significance, but that cases with multiple rigors must be regarded as potential cases of pylephlebitis.

Post-operative rigors, however, were extremely rare, especially where no pre-operative rigors had occurred, this happening in only 3 out of 2841 cases. Two of these died of pylephlebitis, and the other recovered without the cause being discovered. In our series of 5741 cases, post-operative rigors occurred in 8. Six had pylephlebitis, and of the other two, one (*Case* 4) had post-operative pyrexia for thirty days, with a rigor on the seventeenth, and recovered without the exact cause being discovered; the other (*Case* 3) had an intermittent pyrexia for ten weeks, with frequent rigors from the seventeenth to the thirtieth day and a non-hæmolytic streptococcus in the blood; there was no other evidence of portal pyæmia such as signs of hepatic involvement, in spite of the repeated rigors over a long period. Post-operative rigors are, therefore, very rare (1·3 per 1000 cases), and in 8 out of the 11 cases were proved to be due to portal pyæmia and pylephlebitis.

Cholecystitis.—In those cases which have not yet been operated on and in which the signs of the appendicitis are not obvious, the pylephlebitis is most easily confused with cholecystitis on account of shivering attacks, tenderness in the right hypochondrium, and possibly jaundice; both the cases with pre-operative pyæmic symptoms were in fact diagnosed as cholecystitis, the appendix abscess in one case being in the pelvis, and in the other high up behind the ascending colon.

General Pyæmia and Septicæmia.—In *Case* 1 repeated rigors occurred for fourteen days following laparotomy, but there were no signs of hepatic involvement and a non-hæmolytic streptococcus was grown on blood culture. The patient recovered and the condition would appear to have been a generalized systemic blood infection. Brutt reports a similar case of recurrent rigors, which also recovered, with *B. coli* on blood culture. The exact relationship between the infection of the general

blood-stream and the appendicitis is not obvious. It is generally held, though little definite evidence has been brought forward to support it, that the liver acts as a filter to the bacteria, and that a positive blood culture is rarely found in portal pyæmia unless there is a focus already established in the liver, which is in its turn feeding the systemic blood-stream. In *Case* 6 the blood culture was negative though repeated rigors had been occurring for many days. *B. coli* were grown from the blood of *Case* 3, but this was at a late stage, when probably the liver abscesses were well established and giving rise to systemic pyæmia and the multiple lung abscesses and meningitis which were found post mortem. Both the cases of septicæmia had peritonitis, and it is possible that direct infection of the systemic blood took place. On the other hand, the appendicitis may be a localized focus of infection secondary to the blood infection. It is certain, however, that onset of rigors is much more likely to be evidence of portal pyæmia, though occasionally an organism may be grown from the blood at an early stage, in which case the prognosis appears to be better.

Subphrenic Abscess.—The abdominal pain and tender hepatic swelling may cause confusion with subphrenic abscess. However, in Barnard's classical analysis of 76 cases, rigors occurred in only 10, all of which had further complications; 5 pyæmia, 1 cholangitis, 1 periostitis of a vertebra, and 2 a large perigastric abscess communicating with the stomach. Rigors as the presenting symptom are, therefore, unlikely to be evidence of an uncomplicated subphrenic abscess. Should shivering attacks be the initial symptom, it is probable that the subphrenic abscess is secondary to a liver abscess as in *Case* 6 and in one of Barnard's. Recently a case was seen of post-operative pyrexia with onset of rigors after a laparotomy for a perforated duodenal ulcer. There was dullness and diminished breath-sounds at the left base, and a radiograph showed a raised immobile diaphragm. A subphrenic abscess was found on exploration, but autopsy subsequently revealed, as was suspected from these observations on the significance of rigors, multiple abscesses in the liver in addition.

PROPHYLACTIC TREATMENT BY LIGATURE OF MESENTERIC VEINS

Gerster in 1903 advocated exposure and evacuation of thrombosed veins in the mesenteriolum and over the cæcum at the time of appendicectomy in cases of rigors when thrombophlebitis of these veins was found, and reported two successful cases where this procedure had been adopted. He admitted, however, that "on account of the anatomical relations this is sometimes easy, oftener difficult, and mostly impossible".

Wilms in 1907 suggested ligation of the veins in the ileocolic angle, after separating the lower part of the ascending colon from the posterior abdominal wall by inserting a finger under its lateral aspect. He carried this out with a succesful result on a patient who was having recurrent rigors subsequent to drainage without appendicectomy three days previously for an appendix abscess with rigors. However, it is almost impossible to tie off all the veins in the ileocæcal angle through which thrombi may travel without interfering with the nutrition of the bowel, as was illustrated by a later case reported by Sprengel in 1911. 'Wilms' operation' had been performed for repeated daily rigors following appendicectomy

and drainage twenty-one days previously, and the patient developed a cæcal fistula and died later with multiple hepatic abscesses.

Braun's Operation.—Wishing to overcome the objections of Wilms' operation, Braun advised ligature of the ileocolic vein, which he claimed is not difficult to expose, is the only channel through which all emboli must pass to reach the liver from the appendix, and occlusion of which does not endanger the vitality of the bowel. His first attempt in 1907 was unsuccessful, but in 1913 he reported two successful cases in both of which the ileocolic vein was ligatured and several centimetres were resected. In one of these there was an enlarged tender liver and jaundice, showing that even in the presence of these later hepatic changes, if (as he claimed) the feeding focus in the vein below is removed in time, fatal pylephlebitis and liver abscesses may be prevented. Since this date there have appeared several communications in the German literature containing accounts of pylephlebitis complicating appendicitis treated by ligature of the ileocolic vein, a procedure which has become known as ' Braun's operation '. These cases may be divided into those in which ' primary ' ligature was performed during the first laparotomy in cases with pre-operative rigors, and those in which ' secondary ' ligature was performed at a subsequent laparotomy for repeated rigors following the original appendicectomy or drainage.

Primary Venous Ligature.—In *Table I* are collected the previously published cases in which the vein was ligatured at the time of the appendicectomy or drainage. No untoward complications, such as bowel infarction, appear to have followed the venous ligature in any of the cases, and nearly all these authors advocate tying the ileocolic vein in addition to appendicectomy or drainage in cases in which there is evidence of venous involvement as shown by rigors, or early hepatic involvement, or by visible thrombosis in the ileocolic vein or in the veins in the appendicular mesentery or around the cæcum.

A critical study of these cases, however, in spite of the fact that none of them subsequently developed pylephlebitis, shows that one must not too readily conclude that the course of the disease has been greatly altered by this extra interference.

Our discussion on rigors leads us to leave those cases with only one pre-operative rigor out of consideration. In those cases in which there was no thrombosis of the ileocolic cein or its radicles, it is difficult not to believe that the same result would have followed an adequate appendicectomy. Fromme's case was complicated by a large abscess in the transverse mesocolon, which was drained at the same time. Brutt's case had *B. coli* in the systemic blood-stream. Those cases in which rigors continued subsequent to the venous ligature for a long period, though recovery eventually ensued (e.g., Weil's case where rigors continued for three further weeks), are not very convincing. Two died of peritonitis.

Perhaps the most striking was the cessation of rigors and recovery in Sudeck's case of a girl aged 10, who had ten rigors after being ill for eight days with appendicitis. At laparotomy the superior mesenteric vein was found thrombosed and was ligatured proximal to the thrombus after exposure from below through the posterior layer of the transverse mesocolon. In some of the other cases also in which multiple pre-operative rigors had occurred and thrombophlebitis of the veins was found at operation (and jaundice and an enlarged liver in Braun's case) the subsequent cessation of rigors and recovery does suggest that the venous ligature did assist in preventing pylephlebitis from developing.

Table I.—PREVIOUSLY REPORTED CASES OF PRIMARY VENOUS LIGATURE

AUTHOR	PYÆMIC SYMPTOMS	FINDINGS AT LAPAROTOMY	PROCEDURE	RESULTS
Braun 1913	Rigors (several days). Jaundice. Enlarged liver	Appendix abscess. I.C.V. not thrombosed	Drainage. I.C.V. ligatured and 2 cm. resected	Recovery
Braun 1913	Rigors (8 days)	Appendix abscess. I. C. V. thrombosed	Drainage. 8 cm. of I.C.V. resected	Rigors for 4 days. Recovery
Weil 1920	Rigors (2 days)	Appendix abscess. I.C.V. obliterated	I.C.V. ligatured high up. Appendicectomy	Rigors for 3 weeks. Recovery in 10 weeks
Hempel 1923	Rigors (9 days)	I.C.V. palpable	I.C.V. ligatured. Appendicectomy	Further rigors. Recovered
Brunner 1918	Rigors (3 days)	Periphlebitis round I.C.V.	I.C.V. ligatured. Appendicectomy	No more rigors. Recovered
Fromme 1921	Rigors (1 month). Jaundice. Enlarged liver	I.C.V. thrombosed. Intraperitoneal abscess in transverse mesocolon	Abscess drained. I.C.V. ligatured	No more rigors. Recovered
Brutt 1921	Two rigors. *B. coli* in blood culture	Thickened I.C.V. Peritonitis	I.C.V. tied	Recovered
Braunig 1921	Three rigors	I.C.V. not thrombosed. Miliary abscesses in mesenteriolum	I.C.V. tied and resected. Drain	No more rigors. Recovered
Braunig 1921	One rigor	Appendicitis. I.C.V. dilated	Appendicectomy. I.C.V. resected	No more rigors. Recovered
Braunig 1921	Seven rigors	Gangrenous appendix. I.C.V. not thrombosed	Appendicectomy. I.C.V. ligatured	No more rigors. Recovered
Braunig 1921	One rigor	I.C.V. not thrombosed. Appendicitis	Appendicectomy. I.C.V. ligatured	No further rigors. Recovered
Braunig 1921	One rigor	Appendicitis. I.C.V. not thrombosed	Appendicectomy. I.C.V. tied	No more rigors. Recovered
Sudeck 1922	Ten rigors	Appendicitis. Superior mesenteric vein thrombosed	Superior mesenteric vein ligatured	One more rigor. Recovered
Hempel 1923	Rigors (10 days)	Thickened I.C.V. Peri-venous abscess	I.C.V. ligatured. Drained	No rigors. Died, peritonitis
Hempel 1923	Rigors (5 days)	I.C.V. filled with purulent thrombus	I.C.V. ligatured	Died, peritonitis

(I.C.V. = Ileocolic vein.)

The only certain conclusion that can be made regarding the prophylactic treatment of pylephlebitis is that early operation is of the greatest importance. A rigor in appendicitis should be considered just as urgent an indication for immediate laparotomy through a paramedian incision as the onset of peritonitis. There is also evidence that in cases of appendicitis giving a history of multiple pre-operative rigors, if there is visible thrombosis of the ileocolic vein or its small radicles in the cæcal area or early involvement of the liver, additional ligature of the ileocolic vein above the upper limit of the thrombus may assist in preventing an otherwise fatal pylephlebitis from developing. The ileocolic vein can easily be exposed by drawing the transverse colon upwards, the ascending colon to the right, and the small intestine to the left. It will be seen or felt as a thrombosed cord running from the cæcal angle upwards and to the left towards the corner made by the mesentery of the jejunum and the mesocolon (*see Fig.* 249). It is probably best to tie the vein before the appendicectomy. Venous ligature should not be attempted in those cases where circumstances are such that the procedure involves any serious risk of breaking down protective adhesions or spreading the infection in the peritoneum.

Secondary Venous Ligature.—Melchior in 1927 found the ileocolic vein thrombosed almost up to its opening into the superior mesenteric vein at a laparotomy two days after the onset of rigors thirteen days subsequent to an appendicectomy. He tied the vein immediately proximal to the thrombus and the patient recovered, two further rigors occurring five days later. Colp, Braunig, Melchior, Rëok, and Kleinschmidt have each reported a case where this operation has been carried out but without success. However, a careful study shows that in all the cases the ligature was applied after the rigors had been occurring for over a week, and in most of them nearer two weeks. This contrasts with Melchior's and our successful cases, where the thrombosed vein was ligatured within three days of the onset of rigors. It follows, therefore, that the operation, if it is to be performed at all, must be done very soon after the onset of pyæmic symptoms, before the infection has spread beyond the confines of the mesenteric veins.

Now a correct evaluation of the results of venous ligature at a second laparotomy for post-operative rigors is of the greatest difficulty, firstly owing to the great infrequency of the complication, and secondly owing to the lack of knowledge of the exact pathological condition present in those rare cases with similar symptoms which are treated conservatively and recover. Patients with rigors and signs of portal pyæmia after appendicectomy do undoubtedly occasionally recover without a further operation, and even a few well-authenticated cases of recovery from definite pylephlebitis have been described.

But from our study of the ominous significance of rigors and the prognosis of portal pyæmia complicating appendicitis and the dramatic cessation of rigors and recovery in Melchior's and our case following ligature of the vein proximal to the ascending thrombophlebitis, we feel, like many German observers, that this procedure is worth attempting provided it is carried out immediately after the onset of pyæmic symptoms. Post-operative pyrexia with the onset of rigors must be regarded as evidence of portal pyæmia, unless, of course, there are obvious signs of any such complication as pneumonia, pyelitis, cholecystitis, or subphrenic abscess. A second laparotomy should immediately be performed with a view

to ligaturing the ileocolic vein and preventing ascending pylephlebitis. Additional pain or tenderness ascending from the appendicular region, pain on pressure or enlargement of the liver, or jaundice only makes the indication for this prophylactic measure the more urgent. The ligature should preferably be applied to the upper part of the ileocolic vein, near to its junction with the superior mesenteric, well clear of the inflammatory area, where it can easily be identified (*see Fig.* 249). If the thrombophlebitis has already ascended beyond this point, as in our case, the superior mesenteric should be ligatured immediately proximal to the upper limit of the thrombus; to reach this it may be necessary to follow the vein up by dissecting through the posterior layer of the transverse mesocolon. Ligature of the superior mesenteric vein about ¾ in. below its junction with the splenic vein was carried out in our case with success.

CASE REPORTS

REPORTS OF EIGHT CASES OF POST-OPERATIVE RIGORS COLLECTED FROM 5471 CASES OF APPENDICECTOMY

Case 1.—**Appendicectomy. Post-operative pyrexia and rigors. Non-hæmolytic streptococci in systemic blood. Mercurochrome injection into mesocolic vein. Recovery.**

E. T., male, aged 33, was admitted into the London Hospital complaining of pain in the right iliac fossa for one day. Operation by Mr. Donald: gangrenous appendix removed. Peritoneal cavity drained for three days. Remittent pyrexia followed and gradually increased, sometimes reaching 104° in the evening. On the seventeenth day a rigor occurred. Immediate laparotomy revealed a small abscess in the ileocæcal angle which was drained. Pyrexia continued and a further rigor occurred on the twentieth day and recurred almost daily. Blood culture on the twenty-fifth day grew non-hæmolytic streptococci. On the twenty-eighth day a third laparotomy was done through a mid-line incision; 10 c.c. of 1 per cent mercurochrome were injected into one of the veins in the transverse mesocolon. The state of the liver, portal vein, or its tributaries and appendix could not be ascertained. Further rigors for three days only. Intermittent pyrexia continued and slowly decreased till it approached normal six weeks later. Slight pyrexia for three further weeks, and eleven weeks after the last operation the patient was discharged cured.

There were no signs of liver involvement in this case in spite of repeated rigors for fourteen days. Hæmolytic streptococci were grown from the systemic blood. There is no conclusive evidence that portal pyæmia caused the rigors in this case, and the relation of the appendicitis to the blood infection has been discussed in the text.

Case 2.—**Post-appendicular portal pyæmia. Two injections of mercurochrome into portal circulation. Death from multiple liver abscesses.**

A. T., male, aged 18, was admitted into the London Hospital with acute abdominal pain passing to the right iliac fossa which had started about twenty hours previously. Appendicectomy: gangrenous appendix and general peritonitis found. Two drainage tubes. High temperature followed, with onset of daily rigors on the second day. Laparotomy was performed on the seventh day. Liver abscess discovered: 12 c.c. of 2 per cent mercurochrome were injected into one of the veins in the transverse mesocolon. Drainage tube into Rutherford Morison's pouch. Temperature appeared to settle, but rigors recurred three days later (tenth day) and continued. A third laparotomy was done on the thirteenth day and 12 c.c. of 2 per cent mercurochrome were again injected into the portal system. The temperature became lower, but the patient eventually died six days later. Autopsy revealed multiple liver abscesses.

The development of the pylephlebitis was rapid in this case, a liver abscess being found at laparotomy on the seventh day. To hope for any possibility of success venous ligature would therefore have to have been carried out at a very early stage, probably when rigors were the only symptom. There is no note as to when enlargement or tenderness of the liver first appeared.

Case 3.—**Appendicular abscess. Pre- and post-operative rigors. Portal pyæmia. Multiple liver abscesses. *B. coli* in systemic blood-stream. Multiple lung abscesses. Meningitis. Death.**

H. D., male, aged 30, was admitted to the London Hospital with nine days' history of abdominal pain and vomiting, with onset of rigors three days previously. Tenderness in the right hypochondrium was present and the gall-bladder was thought to be palpable. A diagnosis of cholecystitis was made. Laparotomy was performed through a right upper paramedian incision. A high retrocæcal appendicular abscess was found displacing the gall-bladder. The abscess was drained. High pyrexia and rigors continued. *B. coli* was grown from the systemic blood in the later stages. At post-mortem ten weeks later multiple liver abscesses, multiple lung abscesses, a right empyema, and meningitis were found.

A 'primary' ligature of the mesenteric vein might have been attempted in this case, but on account of the position of the abscess the ligature would have to have been applied probably to the superior mesenteric vein to cut off all venous channels leading to the liver. The position of the abscess and the consequent adhesions might have rendered the operation extremely difficult or even impossible.

Case 4.—**Appendix abscess. Appendicectomy. Post-operative pyrexia with one rigor. Recovery.**

C. L., male, aged 32, was admitted to the London Hospital with one day's history of abdominal pain with a rigor. Appendicectomy and drainage. Intermittent temperature continued with one further rigor on the thirteenth day: 40 c.c. of 0·5 per cent mercurochrome were given intravenously. Pyrexia settled two weeks later. The patient was discharged cured.

No definite cause for the pyrexia and rigor was discovered in this case. No conclusive evidence of portal pyæmia.

Case 5.—**Pelvic appendix abscess. Rigors and jaundice. Portal pyæmia. Liver abscesses. Death.**

C. N., male, aged 38, was admitted into the London Hospital with twelve days' history of abdominal pain and shivering attacks. He was tender in the right hypochondrium and thought to be suffering from cholecystitis. Laparotomy: an appendix abscess in the pelvis with coils of small intestine and cæcum matted together was found. Drained. Jaundice, and rigors commencing on the third day followed. Death from pylephlebitis and liver abscesses.

Venous ligature is unlikely to have altered the course of the disease in this case as the patient had already been ill for twelve days, with rigors and a tender liver, before admission.

Case 6.—**Gangrenous appendix. Post-operative pyrexia and rigors. Liver abscesses with secondary subphrenic abscess and right empyema. Death.**

A. W., male, aged 37, was admitted into University College Hospital with abdominal pain and vomiting for twelve hours. Appendicectomy without drainage. Retrocæcal gangrenous appendix, not perforated. Low, irregular temperature followed, and daily rigors commenced on the fifteenth day. On the twenty-second day definite signs of consolidation were present at the base of the right lung. Leucocytosis (W.B.C. 14,000). Blood culture negative. Liver edge palpable and slightly tender. No jaundice. On the twenty-third day a transpleural search was made for a subphrenic abscess, with negative results. A laparotomy was therefore performed through a right upper paramedian incision. The liver was much enlarged and engorged. No pus was found. Irregular pyrexia continued with increasing weakness and delirium. The thoracic wound discharged seropurulent fluid which subsequently became thick green pus. The patient died after six weeks. Post-mortem revealed two large abscesses in the liver, one of which had burst through on the dorsal surface producing a subphrenic abscess: right empyema: pus in the pelvis.

Venous ligature might have been attempted in this case, though it would have to have been done at an early stage when rigors were the only symptoms and no other conclusive signs of portal pyæmia were present.

Case 7.—**Gangrenous appendix. Pre- and post-operative rigors. Death.**

A. H., male, aged 28, a native, was admitted into University College Hospital with two days' history of lower abdominal pain and one rigor. Appendicectomy: gangrenous appendix. High post-operative pyrexia with several rigors. The patient died on the fifth day. A limited post-mortem through the scar showed the local condition to be satisfactory. Thrombosis of the ileocolic vein.

Although complete post-mortem proof was unfortunately not available, the rigors, the absence of peritonitis, and the thrombosis of the ileocolic vein suggest strongly that the patient died of a gross infection of the portal system. As the lieocolic vein was not thrombosed at the original appendicectomy, it is unlikely that ligature of the ileocolic vein would have had any better result than adequate removal of the appendix.

Case 8.—**Gangrenous appendix and peritonitis. Post-operative portal pyæmia and thrombophlebitis of the superior mesenteric vein. Ligature of the vein proximal to the thrombus. Recovery.**

Female, aged 18. This case is, with the kind permission of Mr. Julian Taylor, reported in full in the text.

SUMMARY

1. A case is described of ascending mesenteric thrombophlebitis and portal pyæmia following appendicectomy. Infective thrombosis of the superior mesenteric vein with engorgement and swelling of the liver was found at a second laparotomy. The vein was ligatured proximal to the thrombus, with subsequent complete recovery.

2. The effects of occlusion of the mesenteric veins in man and experimental animals are reviewed. In man the superior mesenteric vein in the region of the transverse mesocolon, or its main branches, including the ileocolic vein, can be tied without producing infarction of the bowel, but occlusion of the small radicles distal to the anastomotic arcade may lead to intestinal necrosis.

3. The significance of rigors in typhlitis and the early symptomatology of portal pyæmia and pylephlebitis are discussed by reference to the literature and to eight original cases. Multiple pre-operative rigors and post-operative rigors are nearly always evidence of portal pyæmia.

4. Ligature of the upper part of the ileocolic and the superior mesenteric vein is discussed as a prophylactic measure against the development of pylephlebitis in cases of appendicitis with signs of portal pyæmia. The operation may be performed as a 'primary' ligature at the time of appendicectomy in cases with pre-operative symptoms, and as a 'secondary' ligature at a second laparotomy when portal pyæmia sets in subsequent to the original operation.

It gives me pleasure to conclude by expressing my sincere thanks for his kind permission to publish his case to Mr. Julian Taylor, whose great personal interest in the case inspired me to prepare this communication. I also wish to express my gratitude to those other members of the staff of the London and University College Hospitals to whom I am indebted for the use of the notes of their cases and for their kindly advice and criticism.

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INTESTINAL OBSTRUCTION BY GALL-STONES

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ACUTE mechanical obstruction of the bowel by a gall-stone is a well-recognized, though uncommon, entity. Undoubtedly most of the gall-stones which gain entrance to the intestinal tract are voided naturally. They cause no symptoms beyond those of the initial attack of biliary colic. Stones which are sufficiently large to cause intestinal obstruction never pass the whole length of the bile-duct, but enter the bowel by a process of ulceration. Such stones are usually more than an inch in diameter. Again, it is probable that a large number of stones which enter the bowel by this method are passed naturally per rectum (*Fig.* 250).

FIG. 250.—This stone was passed naturally by a woman aged 56 years. She gave a history of epigastric pain and flatulence for ten years. She had also had some acute attacks of biliary colic, but had never been jaundiced. It is a pure cholesterin stone and is soapy to touch. The eroded end suggests it had projected for some time into the duodenum and had been eroded by the acid chyme (*Natural size.*)

Some recent figures of the frequency of this condition in relation to the other causes of intestinal obstruction are given later. Earlier accounts of its frequency when causing symptoms place the occurrence rather higher than the recent statistics quoted.

It is interesting to speculate whether the condition is on the decrease in view of the popularity of cholecystectomy at the present time. Alternatively, other forms of obstruction may be on the increase. Owing to the tremendously increased number of abdominal operations performed, it might be supposed that intestinal obstruction by bands would be increasing in frequency, and thus reduce the relative proportion of other causes. This is not borne out by the two symposia quoted below. In 1920–5 the frequency of obstruction by bands was 20 per cent of all causes, while in 1925–30 it was 14 per cent. In 1884 Treves wrote: "An examination of the London Hospital records [of obstruction] shows that cases ascribed to fæcal accumulation are the most numerous, then come cases of stricture of the large intestine, then intussusception, and next in order of frequency, strangulation by bands. Obstruction due to tumours of the bowel ranks next, then follows the blocking of the gut by gall-stones or foreign bodies, while the remaining forms of intestinal obstruction may be spoken of as rare." It is interesting to note that Treves ranks highest intestinal obstruction by fæcal impaction,

whereas in the 1932 review this cause accounted for 17 cases only, i.e., 0·47 per cent. Obstruction by gall-stones is not likely to become very infrequent, as numbers of symptomless cases of gall-stones in the gall-bladder may be discovered at routine autopsies. In such cases there is always the possibility of symptomless ulceration with subsequent obstruction. (*Tables I and II.*)

Table I.—Recent Statistics

Authority	Cases of Gall-stone Obstruction	Total Cases of Obstruction	Percentage Frequency
Vick. (Symposium on Intestinal Obstruction 1932)	47	3625	1·3
Souttar. (Symposium on Intestinal Obstruction 1925)	28	1655	1·7
Meyer and Spivack (1934)	2	505	0·4

Table II.—Earlier Statistics

Authority	Cases of Gall-stone Obstruction	Total Cases of Obstruction	Percentage Frequency
Osler (1900)	23	295	7·8
Leichtenstern	41	1152	3·5
Barnard (1902)	8	360	2·2

SOME POINTS OF SPECIAL INTEREST FROM EARLIER RECORDS

Associated Volvulus.—A gall-stone in the small intestine can excite such vigorous contractions that a volvulus may follow. Mayo-Robson operated on two such cases successfully. It must, however, be an extremely rare phenomenon.

Spontaneous Relief.—A gall-stone after causing obstruction may become free and be voided naturally. This has occurred in a number of cases, but not always with recovery, as a number of patients, after passing the stones, have collapsed and died. A case is mentioned by Treves of a woman of 63 who, after five days of complete obstruction, became relieved and later passed a stone more than an inch in diameter. This patient had an irreducible hernia containing bowel through which the stone must incidentally have passed. The relief experienced in this case was probably due to the stone passing into the cæcum. In another case the stone impacted in a loop of bowel in a hernia, and then ulcerated through the skin.

SUMMARY OF ELEVEN CASES SUBJECTED TO OPERATION

We have been able to review a series of cases subjected to operation, and secure specimens from other cases which, for various reasons, were not referred to a surgeon. A full account of these cases is given on pp. 388–93, but a summary of their main features is convenient at this stage. (*Table III.*)

The only recent comparable series of cases we can find is that of Professor Grey Turner, who in 1927 published a review of eight cases. It is valuable to compare our figures with his, and this has been done throughout the following paragraphs. The earlier literature abounds with records of cases noted as interesting, but few record a definite series of cases. In some of the recorded series cases which were not subjected to operation are confused with those which were, and this rather obscures the issues. In 1910 Sherren edited H. L. Barnard's notes on this condition, with Barnard's series of six personal cases and eight other collected cases. Barnard's article is classic, and should be read by all who are interested in this subject. Some of the earlier cases reported make very interesting reading, and the clinical features are often bizarre. The impression is received that patients in those days were of sterner stuff, when one reads of their recovering from operation on the eighth day of absolute obstruction!

COMMENTARY ON CASES IN THIS SERIES

Age.—The average age of the patients in our series is 66 years, the extremes being 81 years and 44 years. Only three cases were under 60 years of age. In Grey Turner's series the average was 67 years, with extremes of 79 and 56. In his report, however, he refers to a very interesting case of a youth, who, during the seven years between 18 and 25, voided per rectum eight gall-stones, two of which were sufficiently large to require removal with forceps. Subsequently the patient did well. Schuller collected 119 cases; his age limits were 18 and 94 years.

Sex.—It is remarkable that in this series all 11 cases were female. Of Grey Turner's 8 cases, only 1 was male. This gives a combined ratio of 18 to 1, or only approximately 5 per cent of male cases. It is well recognized that gall-stones are commoner in the female sex in any case, but the usual ratios given are 2 or 3 to 1. The earlier writers record male cases more frequently, and Barnard gives the ratio as 4 to 1, or 25 per cent of male cases. He further states that this agrees with the relative frequency of stones in the gall-bladder.

Mortality.—In our series the mortality was 3 out of 11 cases, i.e., 27 per cent. Grey Turner's series showed a mortality of 2 out of 8 cases, i.e., 25 per cent. The mortality of the British Medical Association series in 1925–30 was 70 per cent, while in the 1920–5 series it was 50 per cent. The two cases quoted by Meyer and Spivack both died. The seriousness of the condition is, in our opinion, due to two main factors:—

1. The type of patient in whom the condition occurs. These elderly patients are poor subjects for operation. Some are very obese subjects, while in others, wasting was noted. In two cases—one fatal—sugar was observed to be present in the urine.

2. Operation is not infrequently delayed in these cases, because the obstruction tends to be intermittent. The approximate period of duration of symptoms

Table III.—SUMMARY OF ELEVEN CASES SUBJECTED TO OPERATION

CASE NO.	AGE AND SEX	TERMINATION	APPROXIMATE TIME BEFORE OPERATION	PRE-OPERATIVE DIAGNOSIS	WHETHER SYMPTOMS INTERMITTENT	PREVIOUS HISTORY	SITE OF IMPACTION	WHETHER POSSIBLE TO DISLODGE THE STONE AT OPERATION
1	76 F.	Recovered ..	18 hours ..	Intestinal obstruction. ? cause	No ..	Vague ..	Ileal loop in pelvis	Stone pushed back into healthy bowel and then removed
2	75 F.	Recovered ..	4½ days ..	Intestinal obstruction. ? cause	Marked	Definite history	Lower end of small intestine	Stone pushed back into healthy bowel and then removed.
3	55 F.	Died	? 14 days ..	Intestinal obstruction. ? cause	Not noted	Constipation	4 in. from ileocæcal valve	No note *re* attempt at dislodgement
4	71 F.	Recovered (Stormy convalescence)	6 hours ..	Carcinoma of colon	Not noted	Long history	Terminal ileum ..	Stone could not be dislodged; removed by direct incision
5	62 F.	Recovered ..	4 days ..	Intestinal obstruction. ? cause	Not noted	Definite history	Lower part of ileum	Stone could not be dislodged; removed by direct incision
6	71 F.	Recovered ..	Not ascertained	Intestinal obstruction. By a band	No ..	Not noted	Middle of ileum	Stone was pushed on into a healthy portion of bowel and removed
7	65 F.	Died	48 hours ..	Intestinal obstruction. ? cause	Yes ..	Noted as absent	7 in. from duodenal-jejunal flexure	Stone was pushed on into a healthy portion of bowel and removed
8	57 F.	Recovered ..	20 hours ..	Gall-stone obstruction	Yes ..	Definite history	Middle of small gut	Stone was pushed back into healthy bowel and removed
9	73 F.	Recovered ..	Less than 12 hours	Intestinal obstruction. ? cause	No ..	Absent ..	5 in. from ileocæcal valve	Stone could not be dislodged; removed by direct incision
10	44 F.	Recovered ..	Not ascertained	Gall-stone obstruction	Yes ..	Definite history	8 in. from ileocæcal valve	Stone pushed back with difficulty into healthy bowel and then removed
11	81 F.	Died	36 hours ..	Carcinoma of sigmoid	No ..	Vague ..	Terminal ileum ..	Stone could not be dislodged; removed by direct incision

is listed in the main table. It is impossible, however, to be certain when obstruction became absolute. It will be noticed to be extremely variable.

In the fatal cases in our series it may be noted that :—

One, aged 81 years, was obstructed for 36 hours. She lived 8 days after the operation, developed a fæcal fistula, and died with symptoms of uræmia and ileus.

One, aged 65 years, was obstructed for 48 hours. In this case the obstruction was very high (upper jejunum). She lived for 9 days after the operation.

One, aged 55 years, had intermittent symptoms for 14 days. This patient had a double obstruction. (This will be alluded to later.)

Previous History Suggesting Cholelithiasis.—Four cases of the 11 listed here had a definite gall-bladder symptomatology. In some cases this extended over years. Two others had more indefinite symptoms such as dyspepsia or indigestion, and are listed as ' vague '. In the other 5 no special abdominal symptoms were present and there was little reason to incriminate the gall-bladder. In only 2 cases (18 per cent) was a pre-operative diagnosis of gall-stone obstruction made. One of these had had an attack of jaundice three weeks previously. The cases were subjected to operation because of intestinal obstruction, a common pre-operative diagnosis being carcinoma of the colon. In one case a mass, the impacted stone, was felt in the left iliac fossa and was taken to be a growth in the sigmoid loop.

Site of Impaction of the Stone.—Courvoisier's figures for a series of 53 cases examined at autopsy, are as follows :—

Impacted in the duodenum : 22·2 per cent.
Impacted in the ileum : 65·4 per cent.
Impacted at the ileocæcal junction : 10·0 per cent
Impacted in the sigmoid loop : 2·4 per cent.

In Mr. Grey Turner's series :—

Impacted in small intestine : 87·5 per cent.
Impacted in pelvic colon : 12·5 per cent.

He also separately records a case of obstruction of the transverse colon by a giant gall-stone

All 11 cases in our series had stones impacted in the small bowel—one patient also having a stone impacted in the rectum ; the sites being divisible as follows (the apparent twelfth case is due to one case being one of double obstruction) :—

Upper jejunum : 1 = 8·5 per cent.
Middle of small intestine : 1 = 8·5 per cent.
Middle of ileum : 2 = 17 per cent.
Lower end of ileum : 7 = 57·5 per cent.
Rectum : 1 = 8·5 per cent.

In the cases of fistula we investigated, there is one of duodenal obstruction by fibrosis following a fistula, but we have never seen a stone impacted in the duodenum, although Courvoisier noted 7 cases.

Mode of Ulceration.—It is not always possible, and indeed it is doubtful how far it is desirable, to attempt at operation to decide how the stone gained access to the intestine. At laparotomy a hand was passed up to the gall-bladder region in 5 of our cases : in 4 of these dense adhesions were felt, and it was presumed that a cysto-duodenal fistula was present ; in the other case the gall-bladder appeared to be perfectly normal, and the stone is presumed to have ulcerated through the common bile-duct. It is interesting to note that this was not the

case which presented the previous symptom of jaundice. In 2 further cases there was post-mortem proof that a cysto-duodenal fistula was present. This makes an aggregate of 6 cases of cysto-duodenal ulceration to 1 of common-duct ulceration. In the other 4 cases it is impossible to be certain what form of fistula was present.

Possibility of Dislodging the Stone.—The usual text-book description of this condition concludes with advice that the stone should be moved to a healthy part of the bowel before the gut-wall is opened. We have attempted this in all our cases, but with only partial success. It would obviously be more satisfactory to open the collapsed and relatively healthy part of the bowel distal to the obstruction, than the distended, hyperæmic, proximal portion, and either of these sites is preferable to the actual site of impaction. If the site of impaction is gangrenous it would be best to open this portion and exteriorize the affected part, these patients being too ill to stand resection. Our experience was as follows :—

In 2 cases the stone was successfully pushed on.
In 4 cases the stone could not be pushed on, but was pushed back. (In one with considerable difficulty.)
In 4 cases the stone could not be dislodged at all.
In 1 case no note of the result of this manœuvre was made.

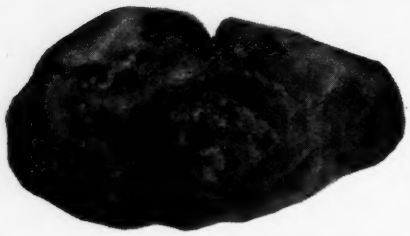


FIG. 251.—*Case* 11. Stone removed from the patient. It is rather more than 2 × 1 × 1 in. When dry it weighed 210 gr. It readily broke into two stones, which have been cemented together by layers of bile pigments. (*Natural size.*)

These findings are usefully compared with the actual cause of the obstruction which is almost certainly spasm of the bowel.

More than One Stone Causing Obstruction.—Double simultaneous obstruction must be exceedingly uncommon, but yet is liable to occur. *Fig.* 251 shows the type of stone which, should it fragment, is liable to produce such double obstruction.

Case 3 is an instructive example. Here the first stone was impacted in the rectum. It was removed, with temporary improvement. Signs of obstruction recurred eighteen hours later, and at laparotomy a second stone was found causing obstruction in the terminal ileum (*Fig.* 252). It can be seen that these stones fit together and so arranged would resemble *Fig.* 251, the stone removed whole from *Case* 11. If this latter stone had broken, double obstruction might readily have occurred. Drew records a patient of 70 in whom two stones were impacted in the upper jejunum at some distance from each other, the second

FIG. 252.—*Case* 3. Stones removed from the patient. The larger stone was impacted in the ileum, while the smaller was wedged in the rectum. The latter was removed digitally. (*Natural size.*)

stone being only found on routine exploration after the first had been removed. The impaction was 18 in. from the flexure. The lower stone did not appear to be causing obstruction, but on the other hand was so tightly wedged that it had to be removed through a separate incision. This case also presented the peculiarity of cystic pneumatosis. It was, unfortunately, fatal, but it should be noted that the obstruction was high. The practical point thus arises that in every case a search should be made for a second stone obstructing, especially if the first removed appears faceted. *Fig.* 250 shows a stone which a patient brought in her hand to hospital, having successfully passed it. It again gives the appearance of two stones joined together. This patient's subsequent history was uneventful.

THE MODE OF PRODUCTION OF BILIARY FISTULÆ

The gall-bladder appears to have a natural aptitude for becoming adherent to structures in its vicinity. The stones in its cavity lead to a pressure necrosis of its wall, doubtless accompanied by a low-grade infection, and in this way a fistula is formed. These fistulæ are most frequently into the duodenum, though they have been described as occurring between the gall-bladder and stomach, colon, renal tract, or even uterus or vagina, while rarely the stones may discharge by a sinus in the anterior abdominal wall. Occasionally, encysted collections of gall-stones are found in the peritoneal cavity. In one rare case a fistula between the liver and lung has been reported, the patient coughing up bile in the sputum.

Courvoisier gives the following result in 36 autopsies on cases of intestinal obstruction by gall-stones :—

	Cases
Fistula to duodenum	25
Fistula to ileum	1
Fistula to colon	1
Fistula to colon and duodenum	2
No fistula	7

Treves is very sceptical as to whether a stone of sufficient size to cause intestinal symptoms can pass via the common bile-duct. He mentions Abercrombie as recording a case in 1837, but throws doubt on this case as the gall-bladder was stated to be " in a state of inflammation and was softened and partially disorganised ".

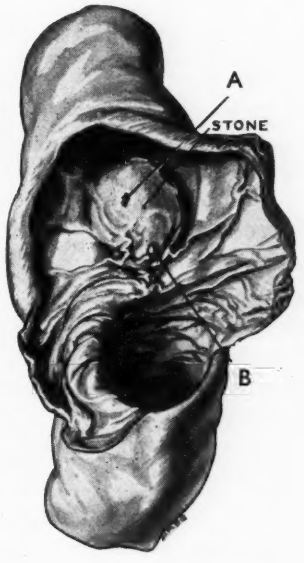


FIG. 253.—The drawing shows the second part of the duodenum opened on the border opposite the entrance of the common bile and pancreatic duct. A stone can be seen impacted in the common bile-duct and beginning to ulcerate through into the duodenum. This stone was $\frac{3}{4} \times \frac{1}{2}$ in. and could cause intestinal obstruction. A, Commencing ulceration ; B, Ampulla of Vater. (The viscera illustrated in *Fig.* 254 are from the same case as this specimen.)

Figs. 253 and 254 are interesting in this respect as showing the beginnings of a fistula where the stone would be of sufficient size to cause obstruction. Here the fistula is between the common bile-duct and the duodenum. This offers a possible solution to the apparent impossibility of a stone large enough to cause obstruction passing the papilla of Vater. The story

of this case is truly remarkable. The specimens came from a man who died from severe burns while on his way to hospital. He had been smoking his pipe in a feather bed when he inadvertently fell asleep. The pipe slipped from his mouth and ignited his bedding. Autopsy showed a cirrhotic liver with obstructive jaundice, a gall-bladder which was full of stones and its wall fibrotic, and a stone impacted in the common bile-duct and about to ulcerate into the duodenum—an extraordinary museum of pathological derangements, and a good example of the occasional rewards of routine autopsies.

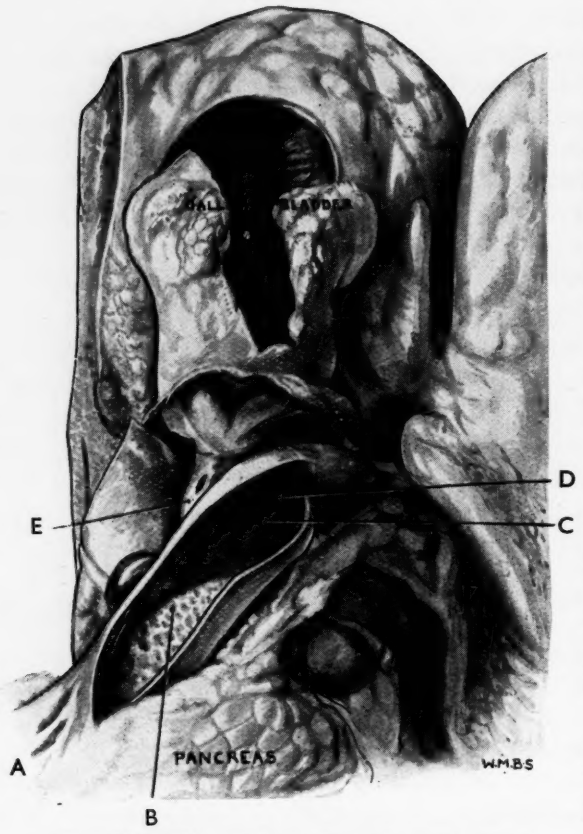
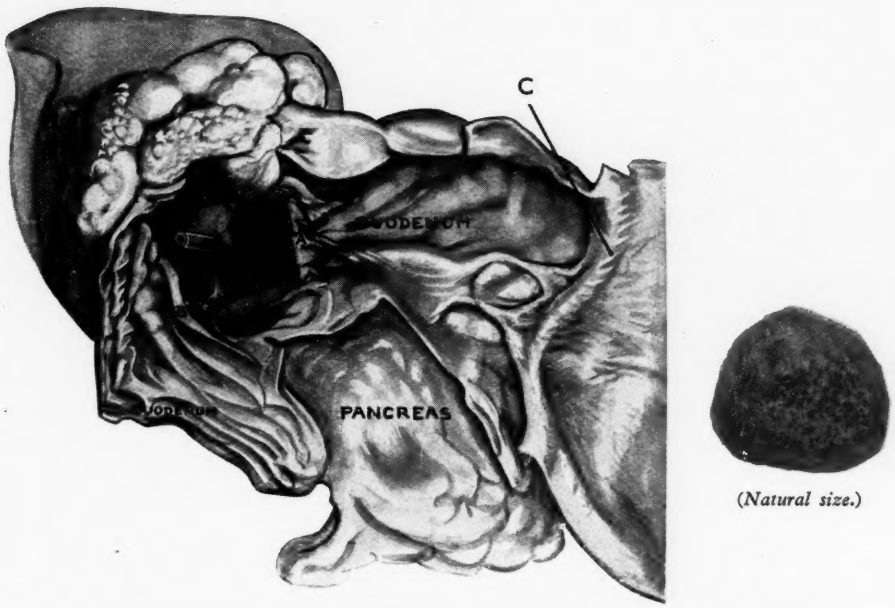


FIG. 254.—This specimen from the same case as *Fig.* 253 shows the liver and biliary apparatus. The gall-bladder wall shows marked fibrosis and the gall-bladder was full of stones. The dilated biliary ducts are well shown. A, Site of obstruction of the stone in the common bile-duct; B, Common bile-duct; C, Common hepatic duct; D, Orifice of hepatic duct; E, Dilated cystic duct.

Multiple fistulæ must be very uncommon, though cases have been reported where the viscus has communicated with the duodenum and colon at the same time. In one case in our series (*Case* 3) autopsy showed two fistulous communications about 1 cm. apart; the upper one small, the lower large and ragged. The stones removed are shown in *Fig.* 252. It was thought at the time that the smaller rounded stone had passed through the upper opening and the large irregular stone through the lower ragged opening.

Figs. 255 and 256 show an extremely interesting specimen where the duodenum was obstructed by cicatrization after the establishment of a cysto-duodenal fistula. This patient, aged 71 years, complained of attacks of vomiting of three weeks' duration. The vomiting was of a very severe nature and unaffected by any diet or alkalis. She had no other symptoms and her previous history was normal, except for an attack of food poisoning nine months previously (the significance of which will be discussed later). A barium meal which showed constant narrowing in the region of the pylorus, with much stenosis and twenty-four hours' residue, had been taken previously. The patient was very wasted and in poor condition. She was admitted to hospital to prepare her for laparotomy, but she sank into coma and died. The illustrations show a large fistulous communication, 1 in. across, between the gall-bladder and duodenum. The duodenal wall opposite the fistula was much scarred and contracted. A stone (*Fig.* 255—inset), lay in the fistula. This measured $\frac{7}{8}$ in. in most diameters and round it were packed



(Natural size.)

FIG. 255.—The specimen illustrates duodenal obstruction by scar tissue following a cholecyst-duodenal fistula. *Fig.* 256 is from the same case. The duodenum has been opened opposite the fistula. A and B denote the marked scar ridges which actually led to the obstruction; C, Pylorus. The glass rod is the same as that shown in *Fig.* 256 and shows the fistulous opening. The recess was occupied by the large stone shown alongside, and six smaller ones not illustrated. The condition is virtually one of hour-glass gall-bladder.

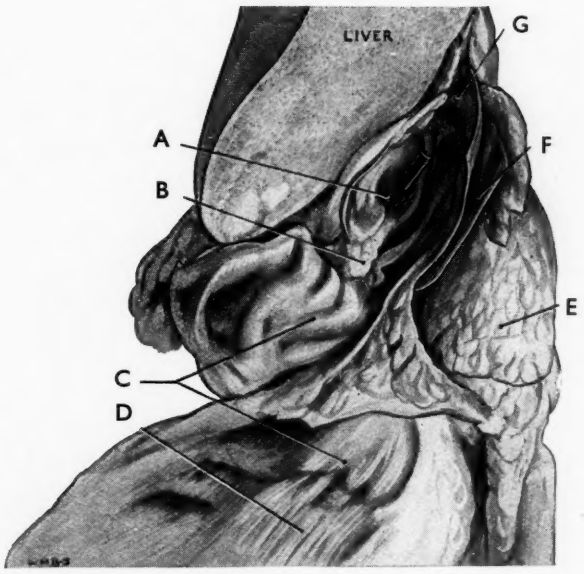


FIG. 256.—This drawing illustrates the other half of the hour-glass gall-bladder shown in *Fig.* 255. The glass rod illustrated is the same as that in *Fig.* 255. It leads from the two parts of the gall-bladder into the duodenum. A, Gall-bladder; B, Adhesions between gall-bladder and duodenum; C, Duodenum (posterior aspect); D, Pylorus; E, Pancreas; F, Common bile-duct; G, Hepatic duct.

several other stones, not illustrated. The duodenal obstruction must have been almost complete. It is probable that the attack of 'food poisoning' nine months previously represented the establishment of the fistula, the subsequent cicatrization leading to the stenosis. It is interesting to consider the symptomatology of the ordinary case with this autopsy finding in mind. The early symptoms are often vomiting, pain, and collapse, the vomitus being gastric contents or bile-stained fluid. This passes off and the patient improves, vomiting recurring later, however, and this time of intestinal contents—the so-called 'fæcal' vomiting. It is reasonable to suppose that the first bout of vomiting is due to the stone entering the duodenum, the intermission being associated with its dislodgement, and the final symptoms being due to its impaction elsewhere. This constitutes the classical story. The obstructing stone itself, as pointed out by Barnard, may often have a narrow nipple-like end composed of pure cholesterin. The pigment layer which would normally cover this was washed away by the chyme while the stone projected into the duodenum. *Fig.* 250, showing a stone which was successfully passed per rectum, demonstrates this erosion.

The Subsequent Fate of the Bi-mucosal Fistula.—After the stone, or stones, have been successfully extruded into the intestine, the fistula begins to contract. This is probably a rapid procedure. Its exact time is difficult to estimate, as the period of delay of the stone in the intestine is very variable. In the autopsies we have seen, the fistula is always far smaller than the stone which passed through it, though the material was examined within a fortnight of the first occurrence of intestinal obstruction. There are cases, however, reported by Grey Turner and others, where, at autopsy, the stone could be returned through the fistula into the gall-bladder. These cases are uncommon, and it is usual to find the fistulous orifice much contracted. *Figs.* 257 and 258 show the typical findings. In this case the stone weighed, when dry, 216 gr., while the fistulous opening is less than ½ in. in diameter. This patient died nine days after the commencement of symptoms. It is thus established that the fistula contracted considerably. The final result is a matter for conjecture. Grey Turner states that it never completely closes, and cites in support of this opinion cases where at the operation of cholecystectomy he has found infundibuliform communications between the gall-bladder and duodenum. He points out the danger of regarding such communications as adhesions, when in actuality they connect with the bowel. Such an end to the condition must be less usual in our experience than for the gall-bladder to shrivel up almost completely. This is illustrated well by *Figs.* 256–259. It may be stated that cholecystectomy should never be undertaken following recovery from intestinal obstruction by a gall-stone.

The Obstructing Stone.—We have earlier pointed out that these stones may be double. The time the stone may spend in the intestine is of interest. The contents of the stomach usually take from four to six hours to traverse the small intestine; we have no reason to believe that once the stone is free it takes any longer. The stone may, however, project into the intestine for some period before it is dislodged. This probably accounts for the wide variations in some of the older accounts in which the establishment of the fistula was confused with the entrance of the stone into the intestine. The illustration from Professor Grey Turner (*Fig.* 259) shows that this may be a lengthy business. Sir Thomas Smith reported a case where the stone was thought to have resided in the intestine for

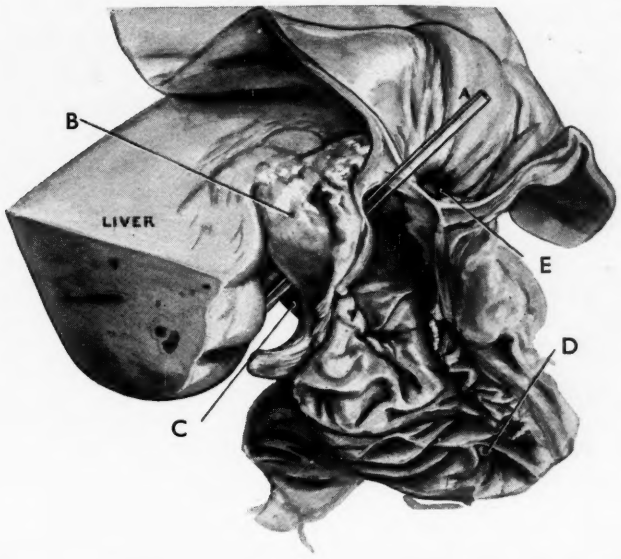


FIG. 257.—*Case* 11. The specimen shows a typical cholescyst-duodenal fistula. The glass rod (A) is the same as the rod A in *Fig.* 258. It passes through the fistula. B, Adhesion; C, Gall-bladder; D, Ampulla of Vater; E, Pylorus.

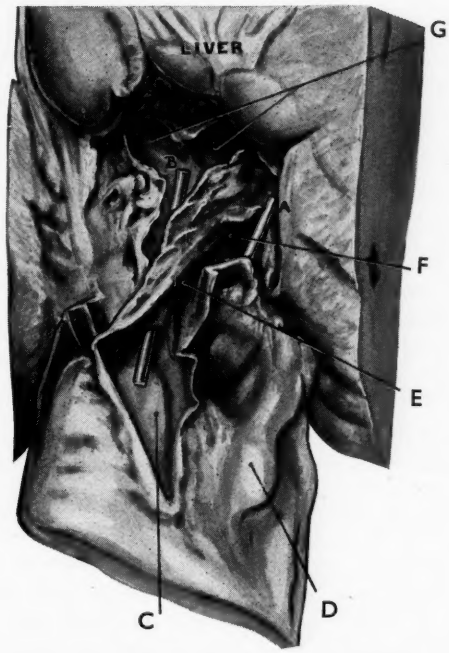


FIG. 258.—*Case* 11. The glass rod A (cf. *Fig.* 257) is in the fistulous opening between the gall-bladder and duodenum. The rod B is passing down the common hepatic duct. The adhesions between the shrunken gall-bladder and the duodenum are well shown. C, Dilated common bile-duct; D, Duodenum; E, Cystic duct; F, Remains of gall-bladder; G, Hepatic duct.

fifteen years. F. S. Eve considered that in one of his cases the stone was in the bowel ten years before obstruction occurred.

It is unusual for the stone to gain accretions while in the intestine. Dr. Charles Newman has kindly assayed the stones of this nature in King's College Hospital Museum, and reports a complete absence of fæcal accretion. Treves, however,

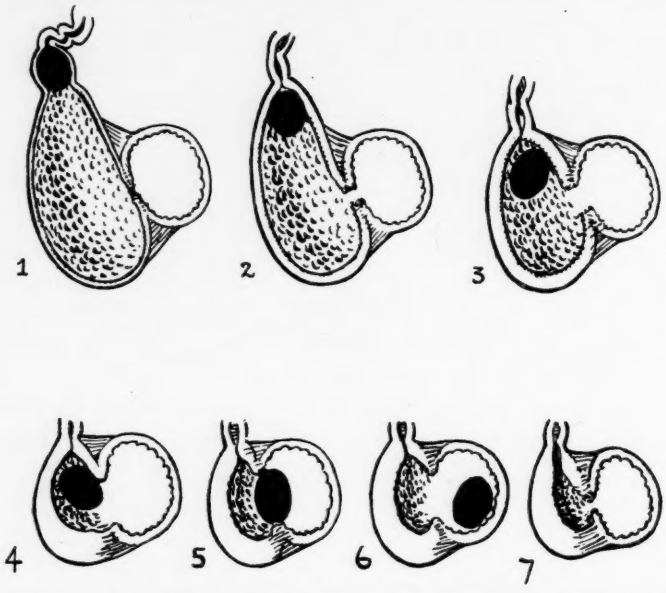


FIG. 259.—A series of diagrams showing how gall-stones may find their way into hollow viscera. 1, A calculus is impacted in the neck of an inflamed and distended gall-bladder which has become adherent to the neighbouring bowel; 2, The gall-bladder has ulcerated into the intestine; 3, The gall-bladder drains freely into the intestine, and, tension being relieved, it begins to contract; 4, The process of contraction, which is partly due to the development of scar tissue, continues and the calculus is pressed against the opening in the bowel; 5 and 6, Show the transit of the calculus into the bowel; 7, The calculus has travelled on down the intestine, the fistula contracts, and the gall-bladder continues to shrivel. (*After Grey Turner, modified.*)

reported a case where a calculus removed from the intestine was composed of a nucleus of a small gall-stone covered in layers by fæcal matter and magnesium carbonate. The stone measured 1½ in. and the patient had been in the habit of taking magnesia for years.

CASE REPORTS

Case 1.—Mrs. Stella J., aged 76, had always enjoyed good health and had brought up a family of four girls and three boys. She was a large woman of 14 stone in weight, but she had led an active life and played golf up to the age of 65. In June, 1919, she first noticed that she had some indigestion after food, but she paid no attention to this. She noticed also that she was inclined to be somewhat constipated, which was not usual for her. On the evening of July 5, at 8 p.m., she was seized with acute abdominal pain, and shortly after this she vomited. Her doctor was called, and as he could not find any definite area of tenderness, he gave her an injection of morphia which eased the pain until 2 a.m. on July 6, when the vomiting and pain returned.

The maximum pain seemed to be situated in the region of the umbilicus. Her doctor saw her at 9 a.m. on July 6 and found that the abdomen was distended, the pulse-rate was 110, and the temperature normal. The patient was sweating and looked ill; she was vomiting about every four hours, and the vomit was beginning to become fæcal in character.

The patient was admitted to a nursing home and an operation was performed at 2 p.m. on July 6. Just prior to operation the stomach was washed out. Gas and oxygen anæsthesia was given, and the abdomen was opened by a right paramedian incision. As soon as the peritoneum was incised, a considerable amount of blood-stained fluid escaped. The small intestine appeared very much distended, and by introducing a finger into the abdominal cavity a hard mass was felt in a loop of small intestine which was situated in the pelvis. The loop of gut was delivered outside the abdominal cavity, and with care the impacted gall-stone was gently milked backwards for several inches into the dilated ileum. An incision was made into the antimesenteric border of the gut over the stone, and the stone was removed. The opening in the gut was sutured by means of a double row of sutures and the gut returned to the abdomen. The liver and gall-bladder were palpated, but no other gall-stones could be felt. The abdominal wall was closed in layers. The patient vomited twice after the operation, but made an uninterrupted recovery.

In this case operation was carried out early and the patient was in good condition in spite of the fact that her doctor gave her ¼ gr. of morphia after the obstruction had become absolute.

Case 2.—E. W., female, aged 75, was seen on Feb. 1, 1923, complaining of abdominal pain and vomiting. She gave a history of fæcal vomiting with abdominal colic and absolute constipation for three days; there was an indefinite history of chronic indigestion, culminating on one occasion with a similar attack thought to be due to gall-stones. On examination the abdomen was distended and the temperature subnormal. She was kept under observation. The bowels were absolutely confined, but there was much less pain and no vomiting. Thirty-six hours later the patient began to vomit material which was definitely fæcal in character; operation was then decided upon.

A median laparotomy was performed. As soon as the peritoneal cavity was opened, distended small intestine protruded through the wound. A large gall-stone, subsequently found to weigh just under ½ oz., was felt in the lower end of the small intestine. The stone was closely held by a ring of spasmodic contraction of the gut; above this the intestine was greatly distended, whilst below it was emptied and narrowed. The stone was pushed up the intestine for a short distance and then removed, and the opening of the gut was closed by two layers of sutures. The patient made an excellent recovery.

This case is interesting in that the obstruction was not absolutely typical in its manifestations. The fæcal vomiting was intermittent, and the pain only severe when the vomiting was present. These facts, together with the actual finding of a ring of spasm gripping the stone, suggest that the intermission was due to the stone passing on for a distance, becoming held up, and then passing on again.

Case 3.—M. T., female, aged 55, was admitted to hospital on March 29, 1923, suffering from intestinal obstruction. The patient stated that she had been well most of her life, but had suffered from occasional 'giddy' attacks during the last fifteen years. She had had almost complete constipation for a fortnight. She stated that she was always constipated, but never as bad as this. On examination the patient was found to be large and fat, with an unhealthy complexion. The skin was moist and cold. The bowels were absolutely confined; the abdominal wall was so fat that palpation was difficult; however, there was marked resonance on percussion, general tenderness, but no rigidity. A soap enema was given with a small result, and the passage of a little flatus. On examining the rectum a large gall-stone was discovered, too large to be passed naturally, and so it was removed digitally. The obstructive signs abated temporarily, and flatus was passed. However, eighteen hours later fæcal vomiting recommenced with abdominal pain. Operation was decided upon.

A mid-line laparotomy was performed, and a large gall-stone, considerably bigger than the one which was removed from the rectum, was found impacted in the lower end of the ileum, about 4 ft. from the ileocæcal valve. There was great distension of the small intestine. The stone was removed, and the intestine closed by two layers of sutures. It was found necessary to puncture the gut with a trocar and cannula before it could be replaced; the puncture was closed by means of a purse-string suture. The patient rallied after twenty-four hours, but died three days after the operation from paralytic ileus.

At autopsy well-marked paralytic ileus was present. The gall-bladder was firmly

adherent to the first part of the duodenum. On opening the duodenum two fistulous communications with the gall-bladder were found about 1 cm. apart. The upper one was smaller, and in all probability the stone which was removed from the rectum had ulcerated its way through it. The lower aperture was large and ragged, and the bigger stone must have forced its way through it. The two gall-stones are shown in *Fig.* 252.

Case 4.—Mrs. Mabel H., aged 71, had enjoyed good health up to the age of 50, when her periods stopped. She was the mother of two girls and a boy, and she had always worked hard in her house and spent a lot of time in her garden and looking after an extensive rock garden entirely by herself. When her periods ceased at the age of 50, she began to have abdominal pain and was jaundiced on three occasions. She visited several continental spas, and underwent many forms of treatment, both at home and abroad, but she did not get any permanent relief. At the age of 60 she was treated for neurosis and enteroptosis and given an abdominal belt. Her appetite became very poor and she began to lose weight. A barium meal did not reveal anything abnormal in the gastro-intestinal tract. About this time she went to live at Brighton and continued in somewhat poor health until the age of 70, when she returned to London in May, 1926. She said she felt better and began to put on weight until Dec. 6, two days after her 71st birthday, when she was seized with violent abdominal pain at 4 p.m. The pain doubled her up and soon afterwards she vomited. Her doctor visited her two hours later and diagnosed intestinal obstruction due to a growth in the colon, and she was admitted to a nursing home. Vomiting persisted and visible peristalsis was seen on more than one occasion. The abdominal distension was not very marked. Rectal examination was negative.

At 10 p.m., on Dec. 6, under spinal anæsthesia, the abdomen was opened by a right paramedian incision; coils of dilated small intestine were discovered, and in the terminal ileum a hard mass was found. The loop of gut was delivered, and an attempt was made to dislodge the stone into the gut above, but this was found to be impossible, so an incision was made over the stone and it was removed. The small intestine was sutured by a double layer of sutures, and the abdominal wound closed in layers. Convalescence was stormy; the patient developed bronchitis and her bowels were only persuaded to act by giving ox-bile enemata every second day. However, she was able to leave the nursing home just twenty days after the operation.

Case 5.—E. W., aged 62 years, a married woman, was taken ill with abdominal pain and vomiting on March 31, 1928. This persisted for four days, when she was seen in consultation and admitted to hospital as an urgent case on April 4. She presented the typical appearance of intestinal obstruction. The temperature was 97°, pulse-rate 100, respirations 20.

FIG. 250.—*Case* 5. Stone removed from patient. (*Natural size.*

The abdomen was distended and tympanitic. Visible peristalsis was noted. Her urine contained sugar (she was later proved to be a mild diabetic). Her past history revealed numerous attacks of pain in the right hypochondrium.

Laparotomy was urgently performed on April 4. The abdomen was opened through a right lower paramedian incision. A gall-stone was found impacted in the last loop of the ileum. It could not be dislodged and was removed by direct incision (*Fig.* 260). A tube

was stitched in to drain the bowel. The upper abdomen was examined and further stones were palpated in the gall-bladder, which was very adherent. The patient made an excellent recovery. The enterostomy closed normally at the end of a fortnight.

Case 6.—S. S., female, aged 71, was admitted to hospital on June 13, 1928. On admission the patient had all the symptoms of acute intestinal obstruction, and was vomiting upper small intestinal contents. There was distension in the upper part of the abdomen, and intermittent colicky pain. No history as regards the investigation of the gall-bladder was taken.

Operation was performed under chloroform and ether anæsthesia. The abdomen was opened through a rectus slide-out incision on the right side below the umbilicus, as a pre-operative diagnosis of small-intestine obstruction, probably by a band, had been made. When the peritoneum was opened there was some free fluid, which was clear. A hand was inserted, and immediately found, about the middle of the ileum, an impacted gall-stone the size of a pigeon's egg. The loop of bowel was then delivered, and clamps were applied above and below the stone. The stone was pushed downwards in the bowel until it reached a healthy portion. The bowel was incised longitudinally, and the stone removed. The hole in the bowel was closed transversely and the abdomen was closed in layers. The operation lasted ten minutes. The patient made an uninterrupted recovery and left the hospital fourteen days after the operation.

Case 7.—P. S., female, aged 65, was admitted to hospital on Nov. 13, 1928. On admission the patient complained of abdominal pain and vomiting of two days' duration. For the previous two days the patient had had intermittent abdominal pain with vomiting. The bowels had not moved for five days. She had always been constipated, but there had been no previous similar attack. She had no urinary trouble. She vomited brown fluid and had passed no flatus per rectum.

On examination the patient had an extremely toxic look. The tongue was dry and furred; the abdomen was distended, tender, and tympanitic, especially under the right costal margin. There was no marked pain. An enema was given with no result. The urine showed a slight trace of sugar.

Operation was performed under gas, oxygen, and ether anæsthesia. A pre-operative diagnosis of acute intestinal obstruction of unknown causation had been made. A rectus slide-out incision was made on the right side, and an exploration carried out. There was much free clear fluid in the peritoneal cavity. The bowel seemed collapsed everywhere. A markedly congested cæcum and appendix were delivered, but no active disease was found. The gall-bladder was found buried in omental adhesions. A gall-stone the size of a pigeon's egg was found impacted in the upper jejunum about 7 in. beyond the junction of the duodenum and the jejunum. This was pushed along into the healthy gut, removed, and the wound in the intestinal wall was sutured. The abdominal wall was closed in layers.

The patient seemed to recover from the immediate operation, and treatment was commenced for her diabetes. She slowly went downhill and died nine days after the operation from hypostatic pneumonia.

Case 8.—Fanny C., aged 57, was admitted to hospital on June 6, 1929. On the afternoon of admission the patient was suddenly seized with intense pain in the right hypochondrium and in the right shoulder. Similar attacks had occurred on several previous occasions. She was sent into hospital as a case of acute cholecystitis. She had vomited stomach contents on two occasions. She was kept under observation, the presumed diagnosis being acute cholecystitis. During the night she vomited again and complained of intermittent colicky pain, still thought to be biliary in origin. Morphia and atropine were administered, and the patient seemed to settle down and was more comfortable the next morning. About 12 noon she vomited again, this time a large quantity of upper small-intestine content. A diagnosis of acute intestinal obstruction by gall-stone was made.

Operation was performed under gas, oxygen, and ether anæsthesia. The abdomen was opened through a trans-rectus incision on the right side, above and below the umbilicus. Some free fluid was found in the peritoneal cavity. There were distended loops of bowel above in the jejunum, and collapsed loops in the ileum. The collapsed loops were traced

backwards to what was taken to be the middle of the small intestine, where an impacted gall-stone was found firmly gripped by the bowel. It was about the size of a pigeon's egg. An attempt was made to push it down into the healthy part of the small intestine, but this was not successful, and the stone was pushed upwards into the distended bowel. The collection of fluid in the upper small intestine was seen rushing into the collapsed intestine below; this process was allowed to go on for two or three minutes, and it very materially emptied the distended loops of bowel. Clamps were applied above and below the stone, the bowel incised longitudinally, and the stone removed. The bowel was closed in two layers longitudinally. The gall-bladder region was palpated along with the common bile-duct and the duodenum, and beyond a marked thickening in the region of the common bile-duct nothing grossly abnormal could be made out. The gall-bladder certainly was quite normal in size and shape, and was not adherent. The abdominal wall was closed in layers, and the patient returned to bed.

Rectal salines were given for the first twenty-four hours, and then a purge of calomel with magnesium sulphate. The bowels acted freely and the patient made an uninterrupted recovery and left hospital twelve days after the operation.

Case 9.—Mrs. Clara B., aged 73, a widow, had spent most of her life in Australia, and came over to England in 1929, at the age of 72, to see her only surviving son, who lived in Surrey. She had always led an active life and was insistent that her trouble began while she was on the boat during the voyage to England. During the voyage she became constipated, suffered from dyspepsia, and went completely off her food, but she did not vomit at all. She lost over a stone and a half in weight during the voyage, and on arrival in England weighed 11 stone 8 lb. She was seen by several doctors, who put her on various diets and, medicines, but without much benefit. She came up to London in January, 1930, with the express purpose of being X-rayed. However, on the way up from Surrey in a car, she was seized with acute abdominal pain and fainted. She was taken to a nursing home and put to bed. Vomiting was incessant, and the abdomen became distended. Rectal examination did not reveal any abnormality in the rectum or pelvic cavity. The stomach was washed out, and operation was performed the same night under spinal anæsthesia. A right paramedian incision was made, and on opening the abdominal cavity, some blood-stained fluid escaped. Loops of dilated small intestine were seen; the cæcum was collapsed. A finger was passed down into the pelvic cavity and a hard mass was felt in a loop of small gut. The loop was brought outside the abdomen, and the gall-stone removed by making a longitudinal incision along the antimesenteric border of the gut. The wound in the bowel was closed by a double row of sutures; the loop was found to be the lower ileum, about 5 ft. from the ileocæcal valve. The abdominal wound was closed in layers.

Recovery was uneventful, and the patient returned to Surrey fifteen days after the operation. Six months later she was in good health and was contemplating returning to Australia. This patient died in 1932 from pneumonia, some two years after her operation, at the age of 75.

Case 10.—Phyllis K., aged 44, was admitted to hospital on Dec. 12, 1931. On admission she was suddenly attacked with acute abdominal pain which came on in spasms. She gave a history of having been troubled with flatulence, and about three weeks prior to admission had an attack of jaundice which passed off. She had vomited on several occasions, at first green bile and then yellow material. She complained bitterly of thirst. She had nine children.

On examination the patient was grossly fat. The pulse and temperature were normal. The woman was very slightly cyanotic. Very little could be made out from abdominal palpation. An actual diagnosis of acute intestinal obstruction by gall-stone was made in this case.

Operation was performed under gas, oxygen, and ether anæsthesia. The abdomen was opened through a rectus slide-out incision on the right side, above and below the umbilicus. Free fluid was found in the peritoneal cavity. The cæcum was delivered and found empty; the small intestine above it was entirely empty. One could feel distended loops of small intestine above. The small intestine was traced backwards for about 6 to 8 in., when a large gall-stone, about the size of a hen's egg, was found firmly impacted in the bowel. At first

it was difficult to move it at all, but finally it was milked upwards into the distended portion of the bowel, and the bowel was squeezed empty with the fingers. Clamps were applied on each side of the stone, and the bowel incised longitudinally. A large foul stone was removed; it was quite soft and mushy. The hole in the bowel wall was closed longitudinally in this case by the two-layer method. The gall-bladder region was palpated, but one could not satisfactorily make out the gall-bladder itself, as the whole area seemed to be bound up in a mass of adhesions. The abdominal wall was closed in layers.

The patient was given copious rectal salines for three days after the operation and made an uninterrupted recovery. She left hospital sixteen days after the operation.

Case 11.—F. M. H., aged 81 years, a married woman, was seized with colicky abdominal pain in the evening of Nov. 30, 1934. She vomited profusely and her bowels were confined. Her past history was negative, except for an illness four years previously, when she had had abdominal pain and an enlarged liver. She was not jaundiced at that time (*see below*). This illness had been diagnosed as a 'malignant liver', and a poor prognosis given. Careful questioning in the light of subsequent findings revealed no further history of biliary trouble.

On examination the patient was found to be thin and wasted, and her general condition was poor. The vomiting had ceased temporarily and the bowels were opened after an enema; much flatus was passed. The abdomen was lax and flabby. There was definite tenderness in the left iliac fossa, where a hard lump could be palpated. This was taken to be a string type carcinomatous stricture of the sigmoid colon. Rectal examination revealed tenderness high up on the left side. A diagnosis of acute obstruction due to carcinoma of the colon was made. Salines were administered, and twelve hours after admission, the patient seemed sufficiently improved to stand operation. It was decided to perform a Paul's type of colostomy. The abdomen was opened through a left-sided muscle-splitting incision, when the lump at once presented, and was found to be ileum containing a large gall-stone (*see Fig.* 251). The stone was firmly impacted and could not be dislodged. The bowel was accordingly opened over the stone, which was extracted. The bowel was allowed to empty on the table, and the wound was then closed by the two-layer method.

For two days the patient rallied and it appeared that she would recover. Then her urinary output diminished in spite of salines. She became increasingly uræmic, and was comatose five days after the operation. She developed a fæcal fistula on the sixth day, and died on the eighth day in coma.

Comment.—It seems reasonably certain that the attack of abdominal pain four years previously was one of cholecystitis, and that the 'big liver' felt and diagnosed as a malignant liver, was actually an enlarged gall-bladder. The gall-bladder then became adherent to the duodenum, and during the last four years a fistula insidiously developed. The post-mortem findings are shown well in *Figs.* 257 and 258, revealing a typical cholecyst-duodenal fistula. The stone removed (*Fig.* 251) could not be returned through the fistula, which had contracted considerably. It weighed 14 grm. when dry.

SUMMARY

1. The frequency of gall-stone obstruction of the intestine is discussed in relation to other cases.

2. Eleven cases of gall-stone obstruction are reported, their clinical features described and analysed.

3. Gall-stones may impact in any part of the intestinal canal and rarely find their way into other viscera.

4. Double obstruction by gall-stones is discussed as a matter of practical importance. The type of stone in such cases is barrel-shaped with a terminal facet. A search should always be made for other stones in cases of intestinal obstruction due to gall-stones.

5. Specimens showing three different types of biliary fistula are described.

Our thanks are due to Professor Grey Turner for permission to adapt *Fig.* 259 from his article already quoted; to Mr. H. C. Edwards for courtesy in affording access to the notes of *Case* 5; and to Dr. C. E. Newman for his kindness in examining the gall-stones submitted to him and for access to the post-mortem material. The drawings are by Miss Mary Barclay-Smith.

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LYMPHATIC SPREAD IN CANCER OF THE RECTUM

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In cases of cancer of the rectum treated by radical excision the prognosis depends to a large extent on whether or not the lymphatic glands contain metastases. Our follow-up records at St. Mark's Hospital now show that in the *A Group*[1] of cancer of the rectum, when the growth is removed by perineal excision before there is gross extension to the perirectal tissues, 91 per cent of the operation survivals are alive after five years. In the *B* cases, in which the growth has extended by direct spread to the perirectal tissues but has not caused deposits in the glands, 64 per cent of patients survive for five or more years. On the other hand, in the *C Group*, with glandular metastases, only 16 per cent of patients surviving perineal excision reach the five-year limit. *Table I* shows the results in the three groups set out clearly, the figure in the last column being obtained from the customary fraction—

$$\frac{\text{Alive at 5 years} \times 100}{\text{Operation survivals less those untraced and died from other causes}}$$

Table I.—Results of Perineal Excision at Five Years Classified According to Extent of Spread of the Growth

Classification of Growth	Total No. of Cases 1927–May, 1930	Died from Operation	Died under 5 Years		Untraced	Alive at 5 Years	Percentage of 5-year Survivals
			Of Other Causes	Of Cancer			
A	24	–	2	2	–	20	91
B	36	1	5	10	2	18	64
C	34	6	3	21	–	4	16

These figures justify the conclusion that in the *A* cases and in the majority of the *B* cases the surgical treatment has succeeded in eradicating the disease. It is obvious that this does not hold for the cases with glandular spread, for among the *C* cases relatively few patients are alive for three or four years after perineal excision of the rectum.

Since so much depends on whether or not the glands contain metastases we decided to make a gland dissection of every rectum excised for malignant disease. Our plan has been to dissect out and remove each gland separately for

microscopic section, marking the position of each on a scale drawing or photograph. We have applied this method in 100 cases: 70 perineo-abdominal and 30 perineal specimens. These dissections have shown very clearly which are the first glands to receive metastases and in which direction the lymphatic spread normally proceeds (*Table II*).

Table II.—CLASSIFICATION OF 100 GLAND DISSECTIONS

	A	*B*	*C*	TOTAL
Perineal excisions	0	9	21	30
Perineo-abdominal excisions ..	7	22	41	70

METHOD OF GLAND DISSECTION

It is possible to make a very complete examination of the extent of spread of cancer of the rectum from operation specimens. The whole rectum and anal canal are removed surrounded by the perirectal tissues and enclosed in the fascia propria or sheath of the rectum. The principal lymph glands lie embedded in the perirectal fat, the connecting lymphatic vessels running beside the main divisions of the superior hæmorrhoidal artery. The perineo-abdominal operation results in the removal of the pelvic colon also, together with a chain of glands at a higher level than is reached by perineal excision.

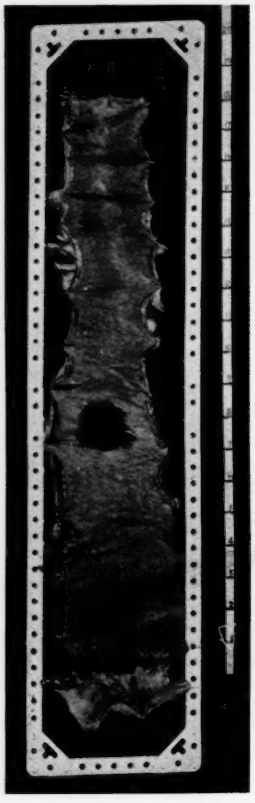

FIG. 261. — Operation specimen stretched on frame for fixation.

Glandular dissection is much facilitated if the operation specimen is opened up with scissors along the anterior rectal wall and stretched out before fixation. Our method has been to use a rectangular frame composed of meccano perforated strips with an adjustable cross-bar. Attachment to this frame was secured by stitching with needle and twine, the sutures being kept taut so that the specimen retained its normal length and breadth (*Fig.* 261). The ligature round the inferior mesenteric pedicle was also tied to the upper end of the frame in order to keep the vessels taut. Stretched on this frame the specimen was immersed for one to two days in a tall jar containing 10 per cent formalin.

A certain amount of patience is necessary in carrying out the gland dissection. In some of our perineo-abdominal excision specimens we have found as many as 60 glands, and the average has been 28. The exact position and size of each gland was marked on a natural-size drawing, using calipers to ensure accuracy in measurement. As far as possible each gland was bisected and one half taken for section, the other being left *in situ*; but with

some of the smaller glands it was necessary to take all for section. The glands were blocked in batches of five. After microscopic examination the position of metastases was marked on the map by inking in the affected glands.

We have used this method of gland dissection in 100 cases, comprising specimens removed by each of the methods of excision of the rectum mentioned above. The dissection of the 30 perineal specimens has been of value in revealing the distribution of cancerous metastases in the immediate vicinity of the growth and the terminal divisions of the superior hæmorrhoidal vessels, but such specimens did not allow an examination to be made of the glands at a higher level. We have learnt more of the distribution of glandular metastases in the upper hæmorrhoidal, inferior mesenteric, and paracolic glands from the dissection of the 70 perineo-abdominal specimens.

LYMPHATIC DISSEMINATION

Frequency of Lymphatic Metastases.—In the total 100 cases glandular metastases were found in 62, the proportion of the metastases in each group of operation specimens being approximately the same.

We were surprised to find in what a high proportion of these cases only a few glands contained metastases. Thus in the total 62 *C* cases one affected gland was found in 13 cases, 2 glands only in 11 cases, and 3 glands only in 7—that is to say, in half the cases with glandular metastases the cancerous deposits were limited to one, two, or three glands only (*Table III*).

Table III.—Number of Glandular Metastases Observed in 62 *C* Cases

Cases with one gland only affected ..	.. 13
Cases with two glands only affected ..	.. 11
Cases with three glands only affected	.. 7
Cases with four or more glands affected	.. 31

The fact that so many patients received surgical treatment in the early stages of glandular dissemination is fresh evidence that rectal cancer spreads slowly from gland to gland. If lymphatic spread had been rapid we should have expected to find the cases falling mostly into the groups with no glands or with several glands involved.

From the surgical point of view it is encouraging to reflect that even when lymphatic dissemination has commenced there is usually a considerable period before the growth may be expected to have spread by lymphatic channels beyond the limits of surgical removal.

Course of Lymphatic Dissemination.—We have been much impressed by the orderly and predictable course of lymphatic spread. The first glands to receive metastases are those situated in the perirectal tissues on the same level or immediately above the primary growth. The next to be affected are the chain of glands accompanying the superior hæmorrhoidal vessels. As a rule these are invaded in sequence from below upwards. In an advanced case the metastases come to form an unbroken chain from the regional lymph-nodes to the glands situated at the point of ligature of the inferior mesenteric vessels.

In all but one of the specimens we have dissected the lymphatic spread has

been by such an uninterrupted upward extension. In the single exception carcinomatous metastases were found in one gland near the point of ligation of the blood-vessels although the chain of glands between this point and the growth were free from deposits (*Case* 19). Wood and Wilkie[2] also reported six cases in which the tumours were situated low down in the rectum and the glands near the upper end of the rectum contained metastases, whereas those near the growth were free. Such apparently discontinous lymphatic extension is found in only a small proportion of cases and may be due to an unusual arrangement of the lymphatic vessels.

We have made a special study of the paracolic glands in order to decide whether or not these ever contain metastases in cancer of the rectum. Miles[3] states that the paracolic glands, situated along the mesenteric border of the pelvic colon, are often the seat of metastatic deposits. This has not been our experience; in fact, we have found metastases in the paracolic glands only in one case. This was a very advanced carcinoma in which metastases were present in all the rectal and hæmorrhoidal lymph-nodes, and the ascending lymphatic vessels were all permeated by a continuous growth of cancer cells. In this specimen we found metastases in one of the paracolic glands and also a downward extension of the growth in the perirectal tissues (*Case* 24). We agree with Miles that lymphatic extension to the paracolic glands is due to blockage of the normal lymph-stream by metastatic deposits, but by the time this has occurred it is unlikely that the disease can be eradicated by surgical excision.

The normal course of lymphatic dissemination may be summarized as follows: the first glands to be affected are those in the immediate vicinity of the growth, after which a continuous spread takes place along the glands accompanying the superior hæmorrhoidal vessels. Until these lymphatic channels are all blocked no downward or lateral lymphatic spread is found, but when carcinomatous metastases are present in all the hæmorrhoidal glands then there may be extension in other directions.

Detection of Glandular Metastases.—In the course of these dissections we have examined more than 2000 lymph glands and thus have had exceptional opportunity for observing to what extent it is possible to determine from the gross characters whether or not lymphatic glands contain metastases. We have made this question the object of special investigation in 1242 glands removed from perineo-abdominal specimens. Our plan was to note during the course of dissection whether or not each gland was judged to contain metastases and then compare the estimate with the verdict which was given later by microscopic examination.

Of these 1242 glands, 905 were considered from gross characters to be negative, but subsequent microscopic examination showed 18 to contain metastases—an error of 2 per cent. On the other hand, in the 337 glands which were judged positive from their gross characters metastases were present actually in only 132, a mistake being made in 205 cases, or 61 per cent of the total. Since a surgeon is inclined to be so much influenced by the discovery of enlarged glands it is important that he should know that conjectures with respect to metastases in the rectal, hæmorrhoidal, or paracolic glands are more often wrong than right. The commonest source of error consists in presuming glands to contain metastases which are enlarged as a result of inflammation.

GLANDULAR DISSECTION AS AN AID TO PROGNOSIS

We have already pointed out that although the general prognosis for patients with glandular metastases is poor, our records show that a certain proportion survive for several years. An apparent though not of course complete explanation of this is that the survivors are patients in whom the lymphatic spread was actually limited to the tissue removed at operation, whereas the deaths occurred amongst those in whom the lymphatic spread had reached a higher level. The method of gland dissection we have adopted now allows a distinction to be drawn between these two groups of cases and a more accurate prognosis based on an examination of the operation specimen. Those cases in which the glandular spread has reached up to the level of the point of ligature of the blood-vessels we classify as *C* 2 cases.

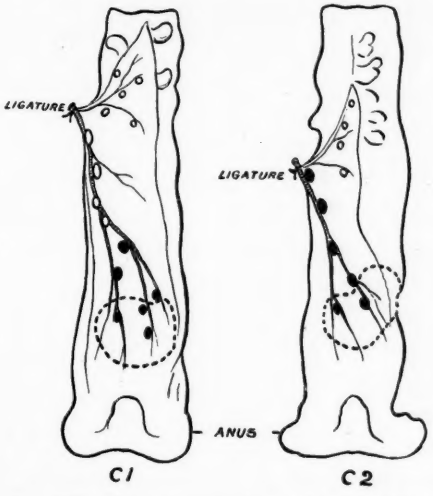

FIG. 262.—Showing examples of *C* 1 and *C* 2 cases.

In these cases the prognosis is bad, there being reason to suspect that glands at a higher level are affected. On the other hand, cases in which the regional lymph glands only are involved, or those in which the upward spread has not yet reached the glands at the point of ligature of the blood-vessels, we classify as *C* 1 (*Fig.* 262). The prognosis is much better for this group, since the disease does not yet appear to have spread by lymphatic channels to the limits of the tissue removed. The application of this method of classification to the 62 cases is recorded in *Table IV*.

Table IV.—SUBDIVISION OF *C* CASES

	C 1	*C* 2	TOTAL
Perineal excision ..	13	8	21
Perineo-abdominal ..	30	11	41

This system of classification takes account only of metastases in lymphatic glands. In a few cases we have found deposits of carcinoma cells at a distance

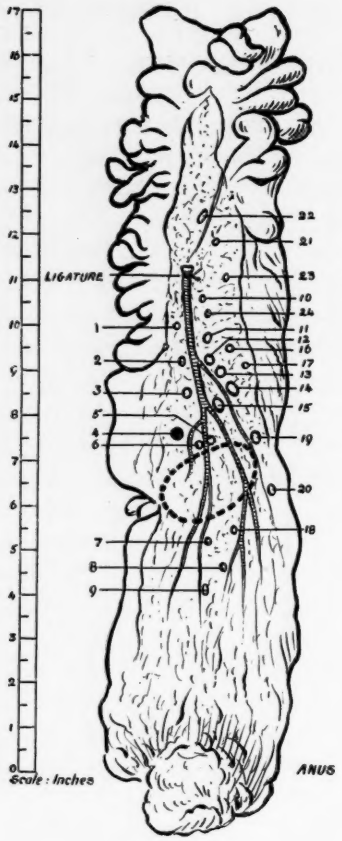

FIG. 263.—*Case* 1.

Case 1.—H. B. E., male, aged 67. A deeply ulcerated growth 2 in. in diameter in the upper third of the rectum. Adenocarcinoma grade 3: metastases in one regional gland. *C* 1 case. (*Fig.* 263.)

Case 2.—W. S., male, aged 67. An ulcerating colloid carcinoma 3 in. in diameter extending completely round the upper third of the rectum. Another small deeply ulcerated adenocarcinoma 1 in. in diameter was present on the right lateral wall just above the main tumour. Spread by direct continuity into the perirectal tissues. Metastases of colloid carcinoma present in one gland. *C* 1 case. (*Fig.* 264.)

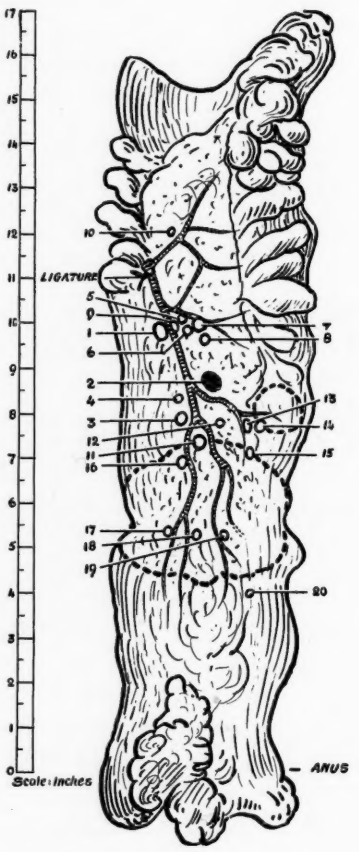

FIG. 264.—*Case* 2.

Case 3.—Mrs. L. D., aged 59. A deeply ulcerated growth 2½ in. in diameter in the recto-sigmoid region, with gross evidence of extra-rectal spread. Adenocarcinoma grade 2. Metastases present in one gland. *C* 1 case. (*Fig.* 265.)

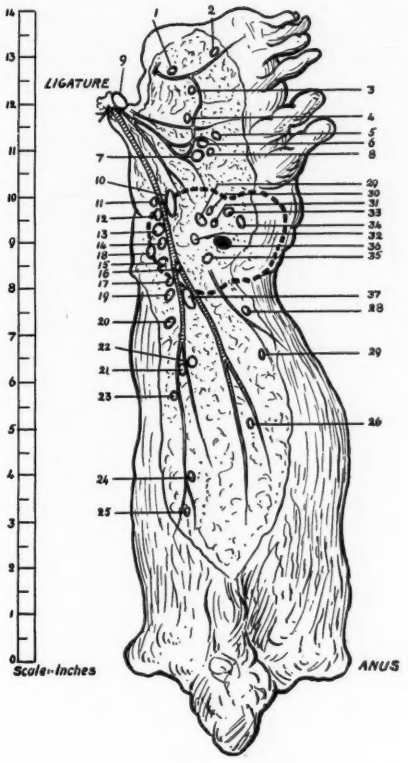

FIG. 265.—*Case* 3.

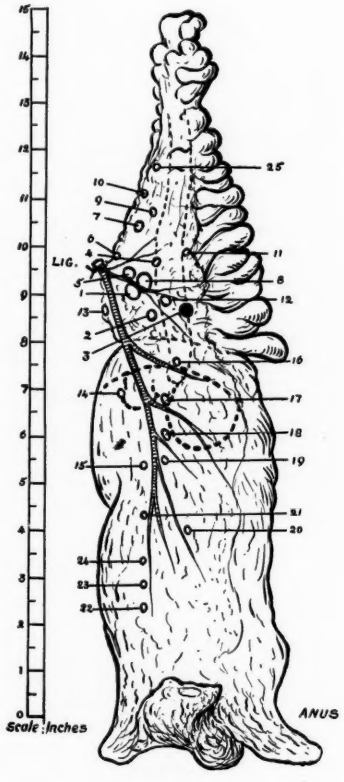

FIG. 266.—*Case* 4.

Case 4.—Mrs. N. D., aged 57. A huge fungating growth in the recto-sigmoid region. Adenocarcinoma grade 2. Metastases present in one gland only. *C* 1 case. (*Fig.* 266.)

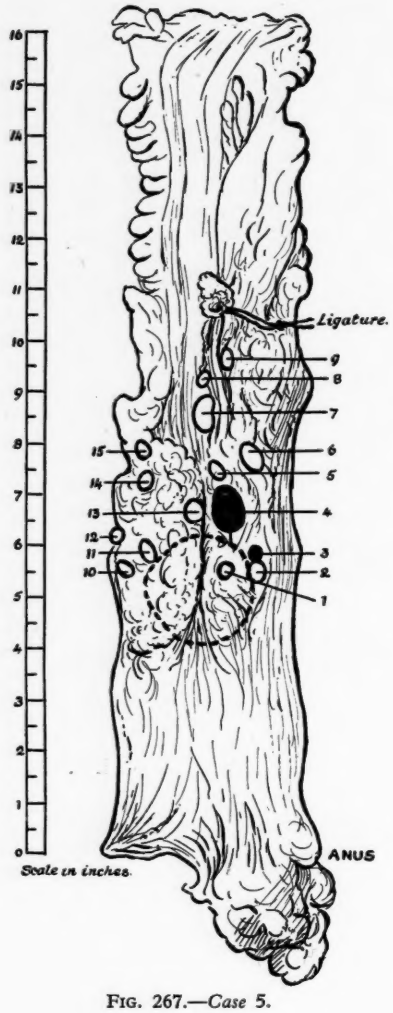

FIG. 267.—*Case* 5.

Case 5.—Mrs. E. C., aged 30. An ulcerating growth 2 in. in diameter in the upper third of the rectum. Adenocarcinoma grade 2. Metastases present in two glands. *C* 1 case. (*Fig.* 267.)

Case 6.—Mrs. E. F., aged 42. An oval ulcerating growth 3 in. in the long axis extended two-thirds round the ampulla of the rectum. Adenocarcinoma grade 2. Metastases present in two lymph-nodes situated immediately above the growth. *C* 1 case. (*Fig.* 268.)

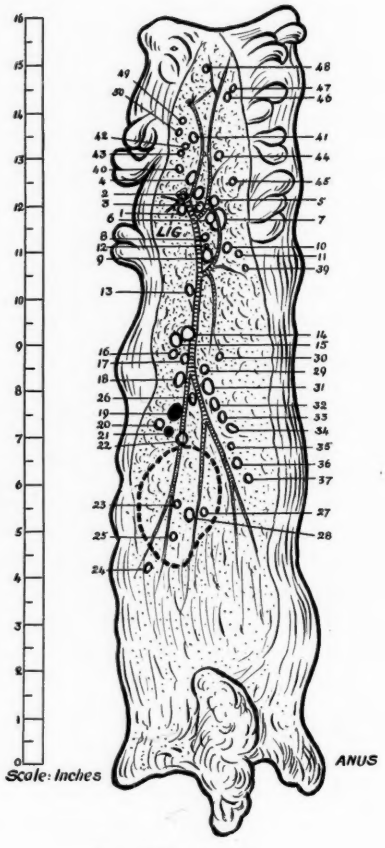

FIG. 268.—*Case* 6.

Case 7.—F. B., male, aged 63. An oval ulcerating growth 3 in. in transverse diameter situated in the middle third of the rectum. Adenocarcinoma grade 2. Metastases present in three regional lymphatic glands. *C* 1 case. (*Fig.* 269.)

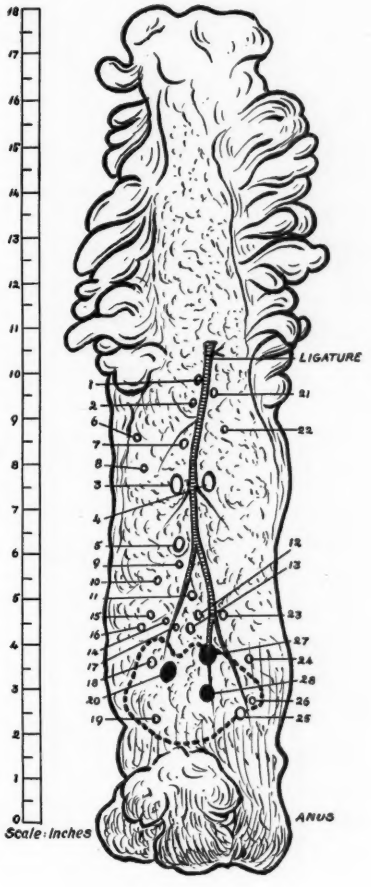

FIG. 269.—*Case* 7.

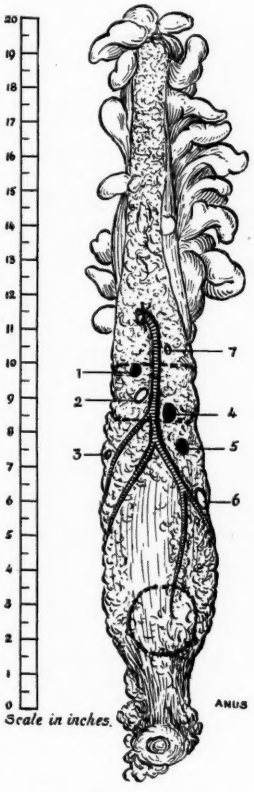

FIG. 270.—*Case* 8.

Case 8.—S. B., male, aged 66. Two ulcerating growths were present, one in the lower third, the other at the recto-sigmoid junction. Both adenocarcinoma. The upper grade 2, the lower grade 3. Metastases present in three glands. *C* 1 case. (*Fig.* 270.)

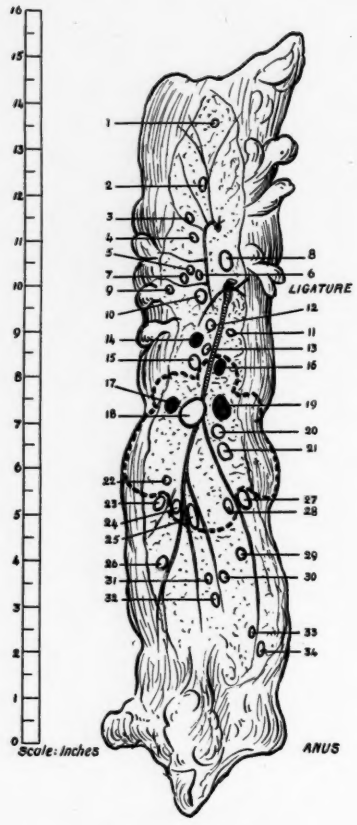

FIG. 271.—*Case* 9.

Case 9.—Miss M. S., aged 34. An ulcerating growth 3½ in. in long axis extended completely round the upper third of the rectum with gross evidence of extra-rectal spread. Adenocarcinoma grade 2. Metastases present in three of the regional glands and in one gland immediately above the growth. *C* 1 case. (*Fig.* 271.)

Case 10.—Mrs. E. S., aged 57. An ulcerating growth extended completely round the upper third of the rectum. Adenocarcinoma grade 2, which has spread by direct continuity into the extra-rectal tissues. Metastases present in four glands. *C* 1 case. (*Fig.* 272.)

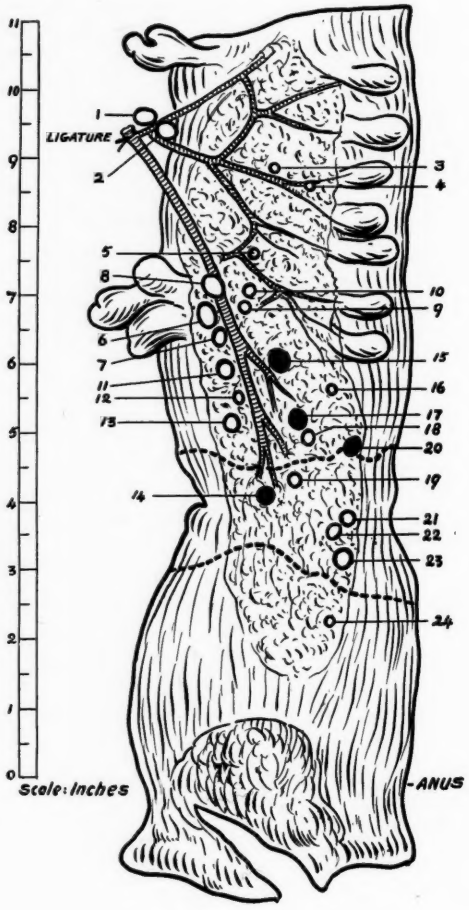

FIG. 272.—*Case* 10.

Case 11.—R. T., male, aged 63. An oval ulcerating growth 3 in. in diameter in the upper third of the rectum. Adenocarcinoma grade 2, with metastases in six regional glands. This patient died of paralytic ileus on the fourth day and at the post-mortem a small secondary deposit was found in the centre of the liver, presumably due to venous spread. *C* 1 case. (*Fig.* 273.)

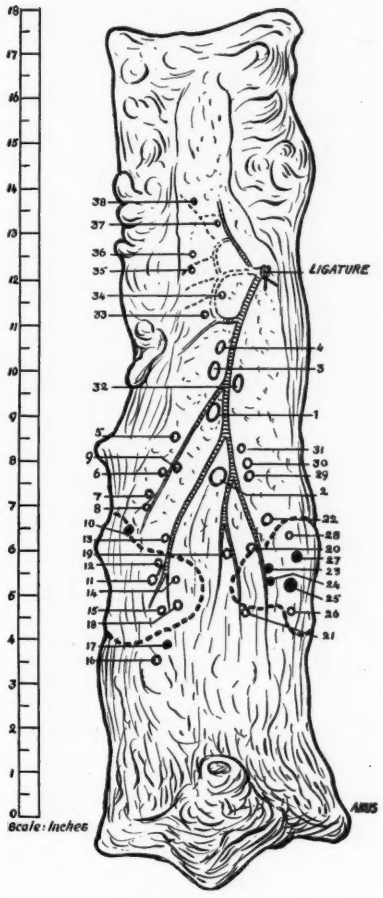

FIG. 273.—*Case* 11.

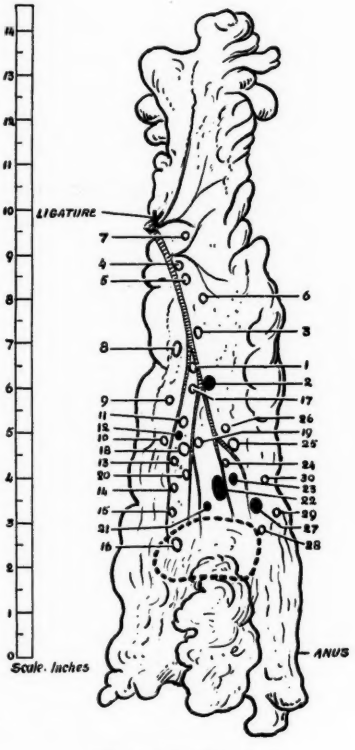

FIG. 274.—*Case* 12.

Case 12.—Mrs. S. R., aged 61. An oval ulcerating growth 2 in. in its long axis extended half round the middle of the rectum, with gross evidence of extra-rectal spread. Adenocarcinoma grade 3. Metastases present in six glands. *C* 1 case. (*Fig.* 274.)

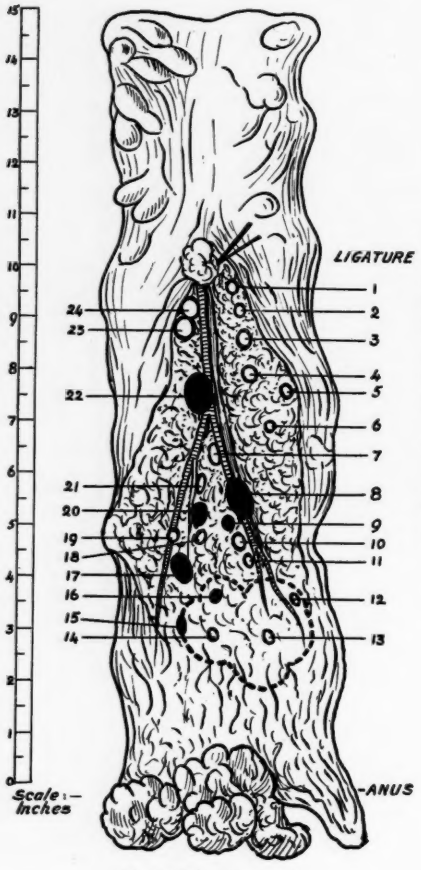

FIG. 275.—*Case* 13.

Case 13.—T. G., male, aged 47. A deeply ulcerated growth about 2½ in. in diameter was present in the lower third of the rectum, with gross evidence of extra-rectal spread. Adenocarcinoma grade 2. Although metastases were present in seven out of twenty-four glands examined, with a large infected gland at the point of bifurcation of the superior hæmorrhoidal vessels, this case can be grouped *C* 1 because there still remain five uninfected hæmorrhoidal glands in the 2 in. which intervene between the upper infected gland and the point of ligation of the inferior mesenteric pedicle. (*Fig.* 275.)

Case 14.—Mrs. E. D., aged 61. An ulcerating growth 3 in. in diameter in the middle third of the rectum. Adenocarcinoma grade 2. A chain of ten glands containing metastases was present along the superior hæmorrhoidal vessels to within 2 in. of the main ligature. *C* 1 case. (*Fig.* 276.)

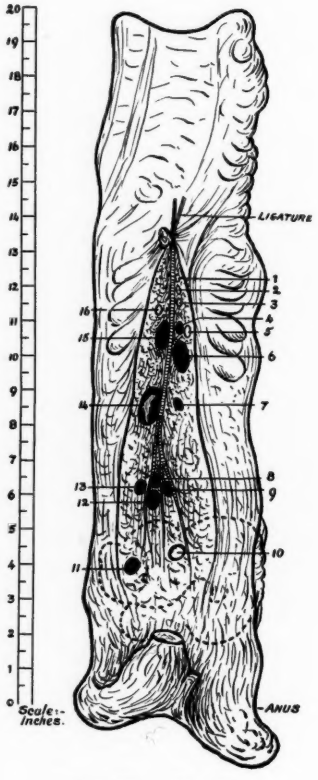

FIG. 276.—*Case* 14.

Case 15.—Mrs. A. W., aged 55. An oval ulcerating growth present in the middle of the rectum. Adenocarcinoma grade 2 with colloid degeneration. Extra-rectal tissues penetrated by direct spread and metastases present in eleven glands. *C* 1 case. (*Fig.* 277.)

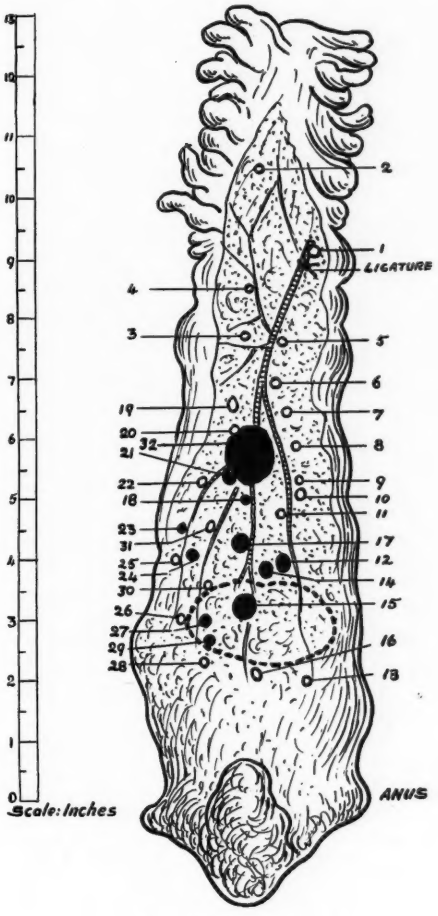

FIG. 277.—*Case* 15.

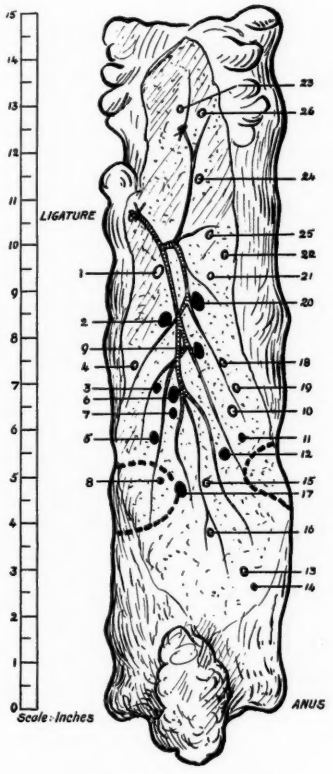

FIG. 278 —*Case* 16.

Case 16.—Mrs. M. A., aged 68. A projecting semi-ulcerated growth 1½ in. in diameter in the upper third of the rectum, with macroscopic evidence of extra-rectal spread. Adenocarcinoma grade 3. Metastases present in eleven regional and superior hæmorrhoidal glands. *C* 1 case. (*Fig.* 278).

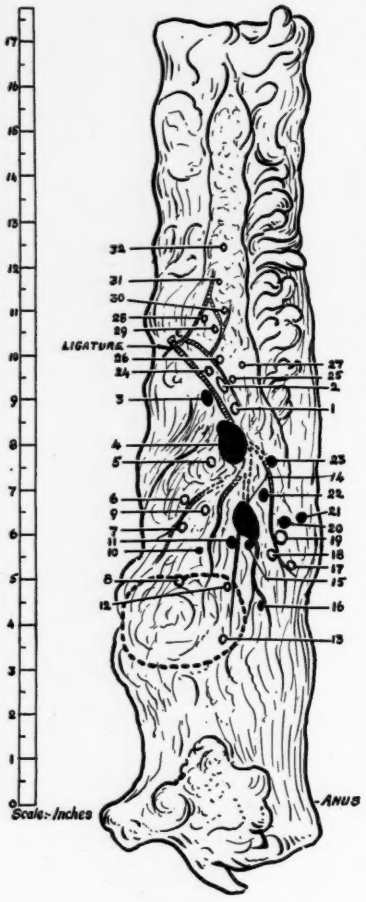

FIG. 279.—*Case* 17.

Case 17.—J. K., male, aged 73. A flat, oval, projecting growth, 3 in. in its transverse axis, extended three-quarters round the middle of the rectum, being situated on the posterior, left lateral, and anterior quadrants. Gross evidence of extra-rectal spread. The tumour is a colloid carcinoma. Metastases present in eleven glands. *C* 1 case. (*Fig.* 279.)

Case 18.—Mrs. A. R., aged 40. An ulcerating growth 2½ in. in diameter extended completely round the lower third of the rectum, with gross evidence of extra-rectal spread. Adenocarcinoma grade 3. Metastases present in sixteen lymph glands. *C* 1 case. (*Fig.* 280.)

FIG. 280.—*Case* 18.

Case 19.—Mrs. Elizabeth H., aged 70. A flat, semi-ulcerated growth 1½ in. in diameter in the lower third of the rectum. Section proves this to be a colloid carcinoma which has spread to the extra-rectal tissues. Metastases present in one gland near the ligation of the inferior mesenteric pedicle. Seven glands below this are free from metastases. *C* 2 case. (*Fig.* 281.)

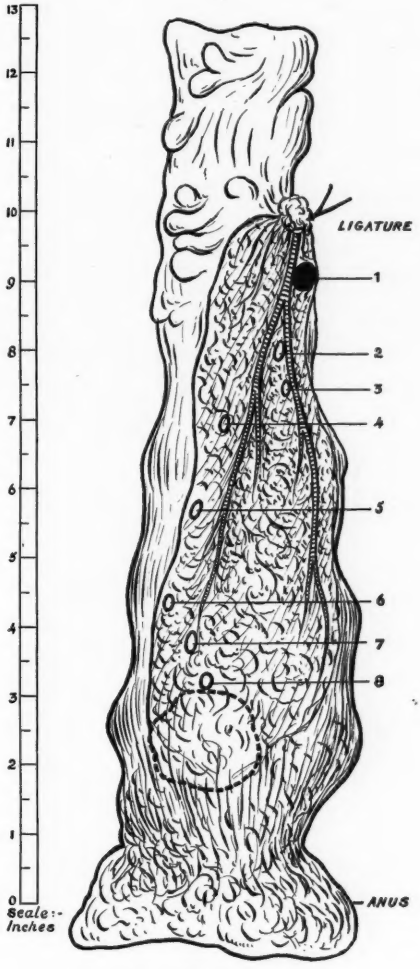

FIG. 281.—*Case* 19.

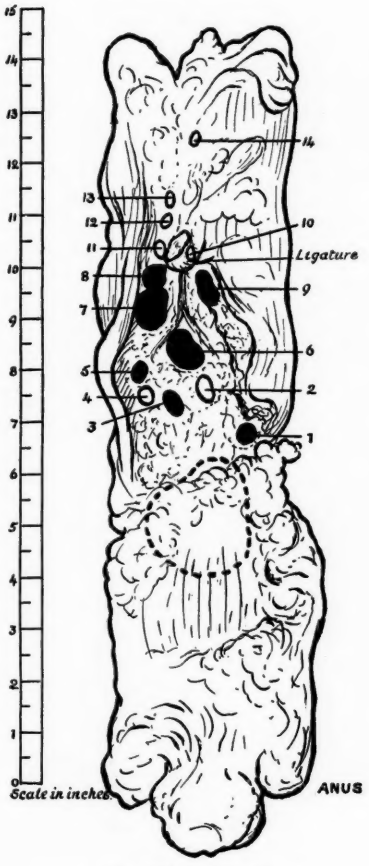

FIG. 282.—*Case* 20.

Case 20.—C. G., male, aged 50. A fungating growth 2½ in. in diameter in the middle third of the rectum. Adenocarcinoma grade 2 which has spread by direct continuity to the extra-rectal tissues. Metastases present in seven regional and superior hæmorrhoidal glands. Four paracolic glands free from metastases. *C* 2 case. (*Fig.* 282.)

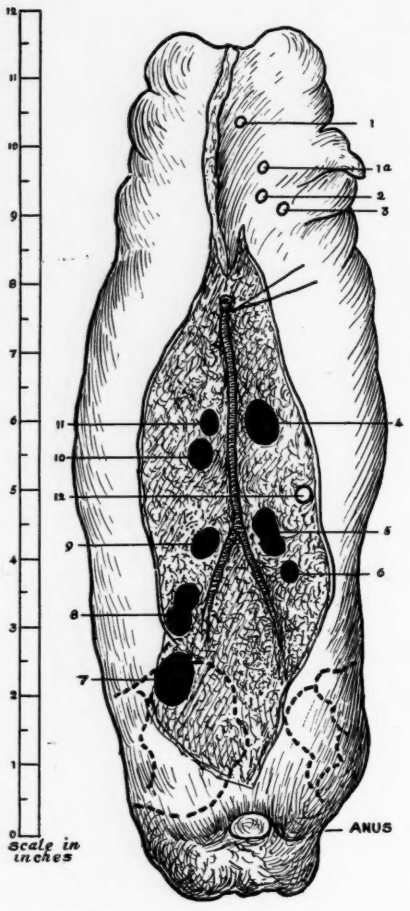

FIG. 283.—*Case* 21.

Case 21.—H. G., male, aged 53. An ulcerating growth 2 in. in diameter extended round the lower third of the rectum. Adenocarcinoma grade 2. Metastases present in eight regional and superior hæmorrhoidal glands. Four paracolic glands free from metastases. *C* 2 case. (*Fig.* 283.)

Case 22.—Mrs. Elsie H., aged 42. A flat ulcerating growth 2½ in. in diameter extended almost completely round the middle of the rectum. Adenocarcinoma grade 3. Metastases in eleven glands. *C* 2 case. (*Fig.* 284.)

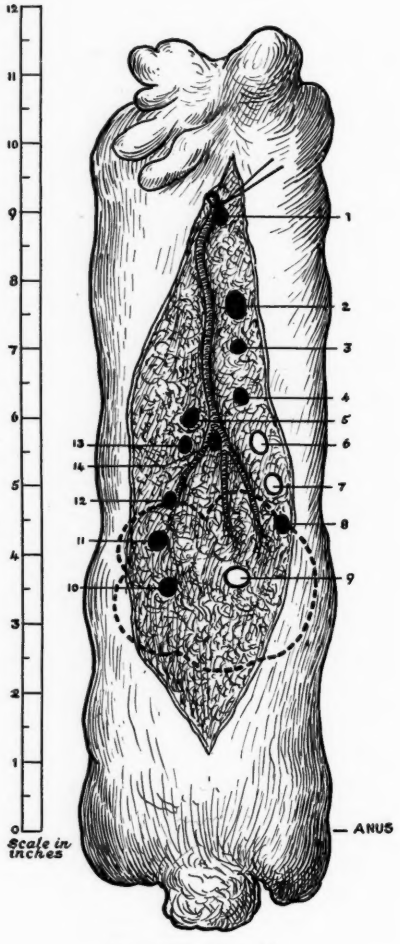

FIG. 284.—*Case* 22.

Case 23.—Miss P. L., aged 71. A huge ulcerating growth 3 in. in diameter extended completely round the recto-sigmoid junction. Adenocarcinoma grade 3. Eighteen regional and superior hæmorrhoidal glands contain metastases, including the glands situated at the point of ligation of the inferior mesenteric pedicle. Malignant invasion of superior hæmorrhoidal vein also proved to be present. Three paracolic glands free from metastases. *C* 2 case. (*Fig.* 285.)

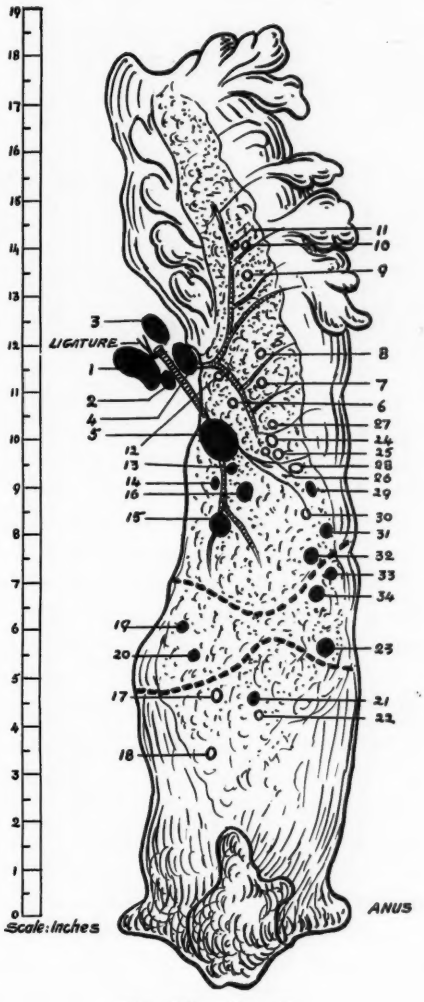

FIG. 285.—*Case* 23.

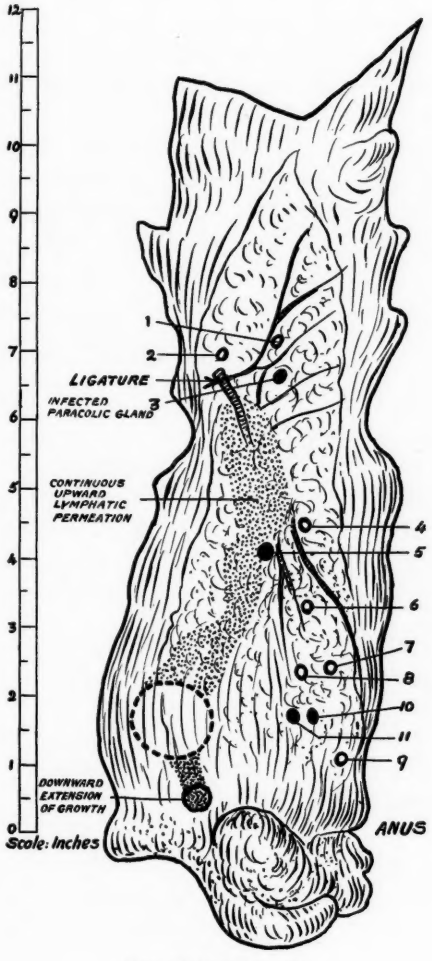

FIG. 286.—*Case* 24.

Case 24.—J. W., male, aged 40. A deeply ulcerated growth less than 1 in. in diameter was situated in the lower third of the rectum, with macroscopic evidence of massive extra-rectal spread. Adenocarcinoma grade 3. Section revealed a continuous mass of upward spread involving glands, lymphatic trunks, and veins. One paracolic gland contained growth. *C* 2 case. (*Fig.* 286.)

from the primary growth although the lymphatic glands themselves have been free. Most of these non-lymphatic metastases are the result of vascular spread. Whenever the lymphatic glands have been free we have grouped the operation specimens as *B* cases and excluded them from consideration in this paper.

ILLUSTRATIVE CASES AND SURGICAL APPLICATION

The characters and course of lymphatic spread can be shown by a series of cases illustrating various degrees of glandular involvement. For this purpose we have selected 24 cases all from the practice of one surgeon (W. B. G.) who carried out the operation in 38 of the perineo-abdominal excisions by the one-stage method previously described (Gabriel[4]). In each case a drawing was prepared by Mr. S. A. Sewell, with strict attention to scale to show the following details: (1) The total length of the specimen from the anus to the iliac colon; (2) The level of ligation of the inferior mesenteric pedicle; (3) The situation and size of the primary growth, indicated by dotted lines; (4) The level of bifurcation of the superior hæmorrhoidal artery; (5) The exact position, shape, and size of each lymph-node dissected out, those proved to contain metastases being marked in black. These 24 cases have been arranged according to the degree of the glandular involvement, beginning with solitary regional metastases and ending with involvement of all the hæmorrhoidal lymph glands. (*Figs.* 263-286.)

Among these 24 cases 18 proved to be *C* 1 and 6 *C* 2. This high proportion of *C* 1 cases is of practical importance and gives the surgeon much encouragement in performing a combined excision of the rectum, even in cases so far advanced as to be of borderline operability. For instance in *Case* 2 the growth was so large and mobility so restricted that little hope was entertained of its being operable, but radical excision by the one-stage perineo-abdominal method proved possible and successful, and by our routine examination metastases have been proved to be present in only one gland at a distance of 9 in. from the anus.

In regard to the extent of lymphatic spread and the radical extirpation of rectal cancer our investigations show the overwhelming importance of the main path of upward lymphatic spread along the superior hæmorrhoidal vessels. In the cases of perineo-abdominal excision illustrated in this article the inferior mesenteric pedicle was ligated at an average height of 10 in. from the anus. When metastases are present in the hæmorrhoidal lymph glands it is obviously advantageous to ligate the vascular and lymphatic pedicle at as high a level as possible.

SUMMARY

1. A method is described for the examination of operation specimens of cancer of the rectum in order to determine the extent of lymphatic spread.

2. As a rule the regional lymph glands are the first to be affected by metastases in cancer of the rectum. Lymphatic spread then proceeds from below upwards along the chain of glands accompanying the superior hæmorrhoidal artery. Irregular or interrupted spread is very uncommon. Lateral or downward lymphatic spread is only found in a late stage of the disease when the hæmorrhoidal lymphatics are blocked by metastases.

3. Examination of operation specimens in the manner described permits a distinction to be made between cases in which glandular spread has already reached the glands at the point of ligation of the inferior mesenteric pedicle (*C* 2 cases) and those in which the upward spread has not extended to this point (*C* 1 cases). We expect that our follow-up records will show that the prognosis in *C* 1 cases is much better than in *C* 2.

4. In the 100 gland dissections we found lymphatic metastases in 62 cases. This is a slightly higher proportion than is usually reported in any series of operation specimens of cancer of the rectum, but it is encouraging to record that the dissection of 70 specimens removed by perineo-abdominal excision showed that only a small proportion (11 out of 70) belonged to the *C* 2 *Group* in which the disease had actually spread by lymphatic channels to the limit of surgical removal.

The cost of the pathological investigations has been defrayed by a grant from the British Empire Cancer Campaign. The expenses of the Follow-up System at St. Mark's Hospital have been met by an annual grant from the Medical Research Council. To both these organisations we wish to express our deep indebtedness.

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THE RÔLE OF SYMPATHECTOMY IN THE TREATMENT OF PERIPHERAL VASCULAR DISEASE*

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Of all the functions of the sympathetic nervous system, that which controls the flow of blood through peripheral arterioles, if not the most important, is at any rate the most conspicuous and the easiest to study. For this reason the present revival of interest in surgery of the sympathetic nervous system has centred largely around the changes in blood-flow which may be caused by appropriate operations on sympathetic nerves. The increasing incidence, or at any rate the increasing recognition, of cases of peripheral vascular disease at a time when interest in the effect of operations upon sympathetic nerves was aroused has led naturally to the use of sympathectomy in the treatment of such diseases. This paper reports our experiences in the treatment of certain peripheral vascular diseases (especially Buerger's disease) by means of sympathectomy.

In all of the three common peripheral vascular diseases (Raynaud's disease, Buerger's disease, and peripheral arteriosclerosis) vasospasm is an element of greater or less importance. In Raynaud's disease the essential basis of the diminished blood-flow is vasospasm. In Buerger's disease and peripheral arteriosclerosis, while the essential lesion is mechanical occlusion of the lumina of certain vessels, there may be a superimposed element of vasospasm. This is of the greatest clinical importance since upon it is based the only form of surgical treatment which offers any hope of success—namely, sympathectomy.

Sympathectomy produces improvement in the obliterative vascular diseases by dilating to their maximum such vessels in the involved extremity as are in spasm. We have no evidence that it causes any change in the occluded vessels. The operation is of value only in those cases in which the accompanying vasospasm is of considerable degree. It becomes important therefore to be able to determine before operation the degree of vasospasm present. This can best be done for the lower extremity by temporary paralysis of the sympathetic nervous system by means of a spinal anæsthetic. The increase in blood-flow which results from this procedure can be measured by the rise in skin temperature of the feet (*Fig.* 287). For the upper extremity, novocain block of a peripheral nerve (e.g., the ulnar) will cause sympathetic paralysis in the sensory area of the nerve, and its effect can similarly be measured by the changes in skin temperature it produces.

On the basis of a personal experience which now extends over about seventy-five cases, it can be definitely stated that these pre-operative tests give information which indicate with considerable accuracy the benefit which may be expected

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* Read before the First Scientific Session of the Royal College of Physicians and Surgeons of Canada, Ottawa, Ontario, Nov. 27, 1933.

from sympathectomy. Generally speaking, the result of operation is somewhat more favourable than might be expected from the preliminary investigation. All patients whose pre-operative tests resulted in an appreciable rise in skin temperature obtained definite benefit from sympathectomy. Frequently the improvement was dramatic. Certain patients in whom the preliminary test produced slight rise in skin temperature obtained an appreciable increase in circulation—sufficient to turn the scale from impending gangrene to rapid healing and to restore the ability to undertake limited activity.

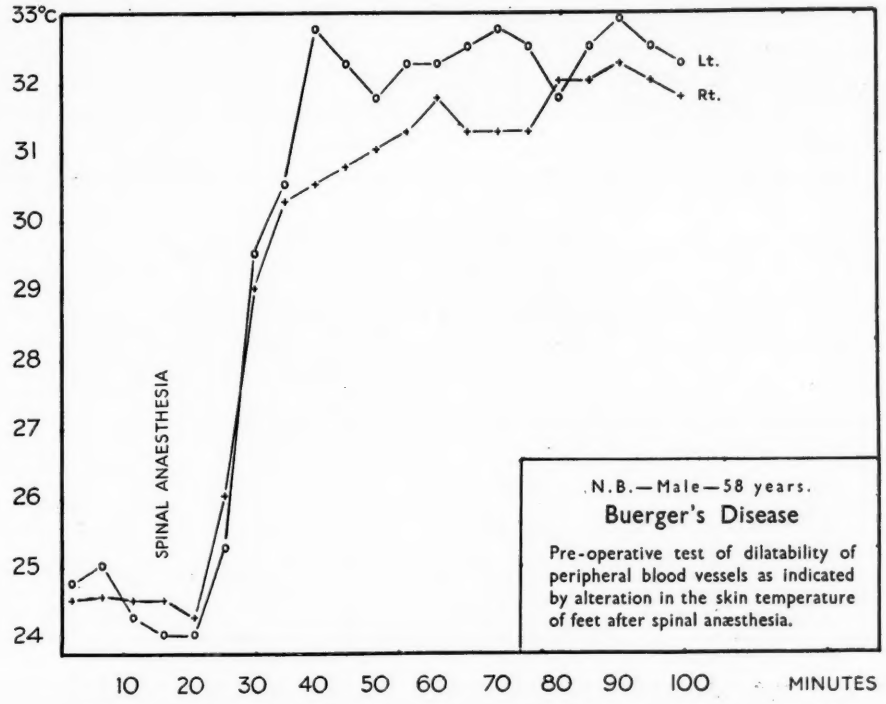

FIG. 287.—A graph of the changes in the skin temperature of the feet following the induction of spinal anæsthesia, indicating a high degree of associated vasospasm and a suitable case for the operation of lumbar sympathectomy.

BUERGER'S DISEASE

In the past four years twenty-four cases of Buerger's disease have been treated by sympathectomy in the Toronto General Hospital. The operations have all been lumbar sympathectomies for the treatment of the disease in the lower extremities, with the exception of three cases in which stellate ganglionectomy was performed for the treatment of the disease in the upper extremity. The ages ranged from 22 to 60 years, the average age being 36 years. All were males. The result of treatment of their disease by sympathectomy has been recently investigated, and the outcome of this investigation is given below. In attempting to judge the benefit obtained by operation we have classified the results in four groups as follows :—

1. *Result good and maintained to the present time.* The immediate result of operation was an appreciable increase in circulation of the extremity as evidenced

by increased temperature, improvement in colour, relief of pain, disappearance of trophic changes, and the healing of ulcers and gangrenous patches. Function was improved so that the patient could return to work or at least could undertake much greater activity than previously. Intermittent claudication, if present, disappeared. This beneficial result is still maintained.

2. *Immediate result good, but too short a time has elapsed to permit accurate assessment of the permanent result.* In all probability the majority of this group will eventually be placed in Group 1.

3. *Immediate result good, but late recurrence has taken place.* The progress of the disease, after varying intervals of time, has caused recurrence of symptoms, disability, and often amputation.

4. *Result poor.* Sympathectomy did not result in any improvement in symptoms, or the persistence of one serious symptom, such as rest-pain, necessitated amputation.

Classified in this manner the results are shown in tabular form in *Table I.*

Table I.—Summary of the Results obtained by Sympathectomy in 24 Cases of Buerger's Disease

	Good	Immediate Result Good. Too Recent to Judge End-Result	Immediate Result Good. Later Relapsed and Limb Amputated	Poor
Number of cases ..	14	5	2	3
Percentage of total ..	58·3	20·8	8·4	12·2
Average age	41	37	28·5	36
Average rise of skin temperature on pre-operative test ..	6·6° C	5° C.	1° C.	0° C.
Extremes: Low ..	4° C.	3° C.		
Extremes: High ..	10° C.	6° C.		

Comment.—Analysis of these results permits important conclusions to be drawn. The most significant evidence is that a considerable number of patients with Buerger's disease can be greatly benefited by sympathectomy. If we include the patients in Group 2 as good results, the number greatly benefited by operation is 79 per cent of the total. The patients in Groups 3 and 4, in which the result was poor, account for 21 per cent of the total. Even here the patients in Group 3 obtained temporary benefit, lasting sometimes two years. They have expressed the opinion that this benefit, though temporary, made operation worth while, even though amputation was later necessary.

The benefit obtained by operation is often dramatic. Not infrequently a patient who is completely crippled by pain and intermittent claudication is so greatly improved that he can return to heavy manual labour. The following is such an illustrative case.

J. J., a Canadian male, 41 years old, was first seen in April, 1932, complaining of pain in the feet and calves. This began five years previously with aching pain in and abnormal coldness of the right foot. The left foot was similarly involved later, and when he was first seen this was the more painful extremity. Severe intermittent claudication occurred after walking two blocks. He had many attacks of migrating thrombophlebitis. Rest-pain was

present in the left foot on admission. He was nearly completely incapacitated by pain and had lost more than 50 per cent of time from his work as a mechanic in the year prior to admission.

Examination on admission showed cold feet with marked postural colour changes. Some lesions of migrating thrombophlebitis were present. There was no pulsation in the pedal arteries of either foot. Spinal anæsthesia caused a rise in skin temperature of 4° C. in the left foot, 6·5° C. in the right foot, indicating an accompanying vasospasm of considerable degree.

As the left leg and foot were the source of much the more severe symptoms, a left lumbar sympathectomy was performed on May 7, 1932. This was followed at once by increased warmth and improved colour of the left foot and the complete disappearance of rest-pain. He returned to work in a few months and continued at this until July, 1933, when he returned of his own accord to have the right side operated upon. During the interval he had worked particularly long hours as mate on a lake freighter, his duties at certain times necessitating his remaining on the bridge for twenty hours at a stretch. A right lumbar sympathectomy was performed on July 12, 1933. Since then he has been continuously at work.

Table I clearly indicates that the result of sympathectomy can be predicted with accuracy from the pre-operative examination. All the patients in Groups 1 and 2 had a rise of skin temperature after the administration of spinal anæsthesia of considerable amount. All the poor results in Groups 3 and 4 had a poor response to spinal anæsthesia. The pre-operative test with spinal anæsthesia provides us with a very accurate measure of the benefit which will be obtainable from sympathectomy.

It is, as yet, too early to predict the ultimate course of these cases. Even though they have been greatly benefited by operation, the basic cause of the occlusive vascular disease remains. It is quite possible that the vascular disease will continue to progress and lead ultimately to recurrence of the disabling symptoms. To date, however, in those cases who have been greatly benefited there has been a gratifying absence of any evidence of progression of the disease. Four years have now elapsed since the earliest case was operated upon. He is still actively engaged in work without evidences of progress of the vascular disease.

PERIPHERAL ARTERIOSCLEROSIS

Though arteriosclerosis usually manifests itself by cerebral, cardiac, or renal lesions, occasionally the most conspicuous lesion is in the extremities. In this event the clinical picture is similar to that of Buerger's disease. An elderly individual of either sex, usually with definite evidence of arteriosclerosis (thickened arteries and increased blood-pressure) begins to display symptoms of diminished blood-supply to the lower extremities. As in Buerger's disease, the vascular lesion here is also occlusive. The degeneration in the media with secondary intimal arteriosclerosis favours thrombosis. Often the onset of symptoms is sudden, as the result of thrombosis in previously damaged vessels. The symptoms are similar to those of Buerger's disease and for similar reasons—muscular fatigue, cold feet, intermittent claudication, postural colour changes, absence of pulsation in the pedal arteries; later rest-pain, trophic changes, and gangrene. In peripheral arteriosclerosis the onset of incapacitating symptoms is apt to be more sudden and more severe than in Buerger's disease because the final factor frequently is thrombosis in a comparatively large vessel. Gangrene, when it occurs, is more massive than in Buerger's disease.

As in Buerger's disease, a certain proportion of the cases of peripheral arteriosclerosis have an accompanying element of vasospasm, and a proportion of these is capable of sufficient improvement by sympathectomy to justify the operation. The number of suitable cases is not great. To begin with, arteriosclerosis affecting chiefly the extremities is relatively uncommon. Of this subgroup only a fraction present the accompanying vasospasm which renders them capable of improvement by sympathectomy. Many cases abruptly develop massive thrombosis with gangrene, which of itself necessitates amputation. Finally, the suitable lesion by the very nature of its pathology is apt to occur in a patient who is a poor subject for surgery. He or she is advanced in years. The active period of his life is probably over, the necessity of work in most cases does not exist. His peripheral vascular disease is but part of a generalized vascular disease which may at any time present much more serious lesions in brain, heart, or kidney.

In spite of all these limitations one does occasionally see patients who are incapacitated by reason of impaired circulation to the extremities due to arteriosclerosis, an impairment of circulation which falls short of gangrene, but incapacitates the patient because of pain and intermittent claudication. Properly selected cases from this group can be benefited by sympathectomy. Suitability is dependent upon the degree of vasospasm, and this is determined by pre-operative spinal anæsthesia or posterior tibial nerve block.

Results of Sympathectomy.—Twelve cases of peripheral arteriosclerosis have been treated by sympathectomy at the Toronto General Hospital in the past four years. The result of this treatment is summarized in *Table II*. For purposes of analysis, the results have been divided into three groups, as follows :—

1. Result good and maintained until the present time.

2. Immediate result good, but further progression of the arterial disease resulted in the return of serious vascular deficiency, usually with gangrene which necessitated amputation.

3. Result poor. Operation did not cause any appreciable improvement in circulation.

Table II.—Summary of Results Obtained by Sympathectomy in 12 Cases of Peripheral Arteriosclerosis

	Good	Immediate Result Good but Relapse Occurred and Limb Amputated	Poor
Number of cases	5	1	6
Percentage of total ..	41·66	8·4	50
Average age	62	70	64
Average rise of skin temperature on pre-operative test	6·2° C.	1·5° C.	0·7° C.
Extremes : Low ..	3° C.		0° C.
Extremes : High ..	10° C.		3° C.

Comment.—These twelve cases comprise all the cases of peripheral arteriosclerosis treated by sympathectomy during the period we have been interested in this form of treatement. The figure includes patients operated upon before

the value of pre-operative tests was established and patients operated upon in spite of unfavourable pre-operative tests in the hope that some benefit might be obtained sufficient to avoid the necessity of amputation. That this hope was not without some justification is evidenced by the single patient in the second group, whose history in summary form is as follows :—

H. L., a Jewish male, 70 years old, for two years prior to admission had been increasingly disabled by cold painful feet, intermittent claudication, rest-pain, and finally gangrene of the tip of the great toe with infection. Colour changes were marked. Posterior tibial nerve block yielded a skin temperature rise of only 1·5° C. Nevertheless, sympathectomy was performed on Nov. 28, 1930, with great benefit. Rest-pain disappeared at once. The gangrenous spot promptly separated and healed. Skin temperature improved. He was able to walk several blocks without discomfort, whereas before operation he was incapacitated by intermittent claudication after walking half a block. This improvement was maintained for a year. Then pain and claudication recurred, though to a less severe degree than before his operation. Two years after operation gangrene again threatened the foot, and for this and for pain his leg was amputated.

Sympathectomy postponed amputation for two years and gave this man one year of complete comfort and another year of comparative freedom from symptoms.

Perhaps the most important finding in this analysis is the evidence that by pre-operative tests it is possible to determine with considerable accuracy the effect of sympathectomy upon a given patient. In every case in which the result of operation was good (Group 1) the pre-operative test resulted in a sharp rise in skin temperature, never less than 3° C., and usually higher, the average rise being 6·2° C. The reverse was true in those cases in which the result of operation was poor (Groups 2 and 3). In all these the pre-operative tests gave feeble increase in skin temperature, never more than 3° C., and usually less. Our experience leads us to feel strongly that in any case of peripheral arteriosclerosis which seems suitable for sympathectomy, pre-operative skin temperature tests, by spinal anæsthesia or posterior tibial nerve block, will determine accurately the benefit which will follow operation.

In the favourable group the benefit obtained is often great, sometimes dramatic. The instant relief from the intolerable rest-pain is very striking and transforms the patient from a sleepless pain-wracked invalid to a contented being. Unhealed wounds and small patches of gangrene rapidly heal. The degree of benefit can best be visualized by the relation of one or two case histories.

J. T., an Englishman, 63 years of age, for a year had been incapacitated by cold painful feet, intermittent claudication, rest-pain, and finally by the onset of gangrene of his right great toe. Postural colour changes were marked. No pulse could be felt in the dorsalis pedis or posterior tibial arteries of either foot. Pre-operative tests gave a rise in skin temperature of 4° C. He refused operation and left hospital. A month later he returned, driven by the intolerable rest-pain to a willingness to submit to anything. The gangrene of the great toe had extended to the metatarso-phalangeal joint. Right lumbar sympathectomy was performed in April, 1930, and the gangrenous toe was disarticulated at the metatarso-phalangeal joint. Operation was followed immediately by complete disappearance of the rest-pain. The wound of the toe slowly healed. It is now three and a half years since operation. The temperature of his right foot is maintained at higher level than the left. He is free from discomfort and leads a life of moderate activity. To date there is no evidence of recurrence of vascular insufficiency.

A. S., a Canadian male, 68 years of age, was incapacitated by intermittent claudication of two months' duration in the left leg. The onset of this had been abrupt, and the symptoms

so severe as to prevent him completely from working as a labourer. There was no pulsation to be felt in the dorsalis pedis artery on either side, but that in the posterior tibial could be felt on both sides. No postural colour changes and no trophic changes or gangrene were observed. Pre-operative test with spinal anæsthesia gave a skin temperature rise of 10° C. Left lumbar sympathectomy was performed in May, 1931, with immediate and very beneficial results. His incapacitating intermittent claudication completely disappeared and he was able to return to work as a labourer. To date, two and a half years after operation, the improvement is maintained. He is still at work and has no symptoms. The warmth of the foot is maintained.

The abrupt onset and the severity of this man's symptoms suggest that the final interference with circulation was thrombosis in a vessel supplying a relatively small field, perhaps chiefly to muscles.

RAYNAUD'S DISEASE

Our experience with the treatment of Raynaud's disease by sympathectomy has been too meagre to permit us to draw any definite conclusions based upon our own patients. Raynaud's disease is uncommon. Though cases of minor severity are occasionally seen, the more severe forms, of a degree which would justify the risk of operation, are very infrequent. Moreover, they may present themselves in bizarre forms which renders classification difficult. This purely vasospastic form of vascular disease should be particularly suitable for treatment by sympathectomy, and the reports in the literature support this contention. Our experience is limited to four cases. One of these conformed exactly to Raynaud's original description—a middle-aged female disabled by recurring attacks of blanching of the fingers induced by cold, followed by painful cyanosis, and resulting in trophic ulcerations of the finger-tips. The remaining three cases presented features in addition to the recurring attacks of vasospasm which complicated the diagnosis. All were benefited by sympathectomy. While our experience with Raynaud's disease is limited, we feel it is singularly suited to treatment by sympathectomy. Case histories of three patients follow:—

J. F., a Canadian male, aged 58 years, had been incapacitated for four years by recurring attacks of painful blanching of the hands and feet followed by purplish discoloration. A trophic ulcer was present on the left leg. An unusual feature was the extreme degree of œdema present in both feet. Pulsation was present in both radial arteries, both dorsalis pedis arteries, the right posterior tibial artery, but was absent from the left posterior tibial artery. Left lumbar sympathectomy was performed with benefit. The ulcer healed promptly and he was made more comfortable. The œdema is unchanged and the attacks of blanching still occur in the hands.

E. S., a Canadian female, aged 24 years, since childhood had suffered from severe attacks of vascular spasm induced by cold and involving all four extremities and all the exposed parts of the body—nose, ears, cheeks, chin, and knees. Trophic changes were very marked. By repeated ulceration she had lost innumerable small patches of skin from the involved parts of the body. Pulsation was present in all the palpable arteries. Pre-operative test by spinal anæsthesia gave a skin temperature rise of 8° C. Right lumbar sympathectomy performed in April, 1931, resulted in well-marked increase in circulation of the right leg and foot, but did not prevent the recurrence of trophic ulceration during the ensuing winter. Improved but not cured by operation.

J. B., an Englishwoman, 57 years of age, for five months prior to admission had suffered from attacks of cyanosis and coldness of the toes of the right foot, especially the little toe. There was no pain or intermittent claudication. Pulsation was felt in all the pedal arteries. Pre-operative test with spinal anæsthesia gave a skin temperature rise of 5° C. Right

lumbar sympathectomy performed in October, 1931, was followed by striking improvement in the involved foot. This case gave promise of a complete cure. The patient, however, developed cerebral thrombosis and died one month after operation.

OPERATIVE TECHNIQUE

It may not be inappropriate here to outline briefly our operative technique, since technical difficulties can be greatly reduced by a proper approach.

Lumbar Sympathectomy.—In removing the lumbar sympathetic chain our preference is for the extraperitoneal approach first advocated by Royle. The transperitoneal approach is not without danger of intraperitoneal complications, and it fails to give adequate exposure of the upper portion of the lumbar trunk.

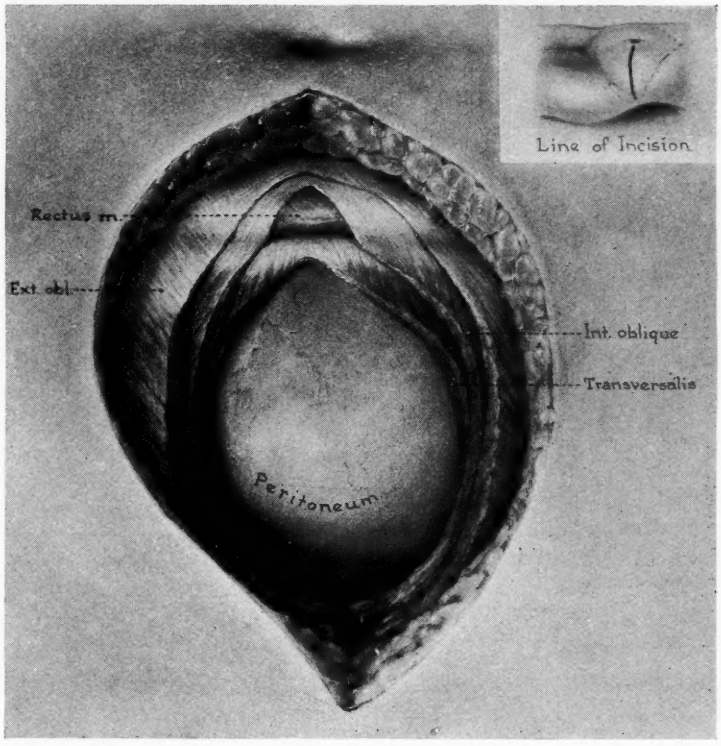

FIG. 288.—The transverse abdominal incision for the extraperitoneal approach to the lumbar sympathetic chain.

Royle's oblique incision in the loin necessitates the removal of the chain through a deep narrow wound. In stout adults this can be a difficult technical procedure. For this reason we have modified the approach (*Fig.* 288). Exposure is much superior and the operation much easier if carried out through a transverse incision extending from the umbilicus to the edge of the quadratus lumborum muscle. The three muscles of the anterior abdominal wall are cut through transversely in the line of the skin incision, and the sheath of the rectus is cut without severing the muscle. This permits the peritoneum to bulge into the wound. Hæmostasis is secured and skin towels are applied. With the hand, the peritoneum is swept free

from the lateral and posterior abdominal wall and displaced towards the mid-line. It is a mistake to attempt to free the peritoneum completely from the anterior abdominal wall. It is densely adherent to the posterior sheath of the rectus and to the linea semilunaris. The attempt to separate it here always results in tearing it. The opening in the abdominal muscles is widely retracted upwards and downwards, and the peritoneum with the abdominal viscera held to the mid-line by the assistant's hands. This brings clearly into view the quadratus lumborum and psoas muscles. The ureter is displaced with the peritoneum (*Fig.* 289, 290).

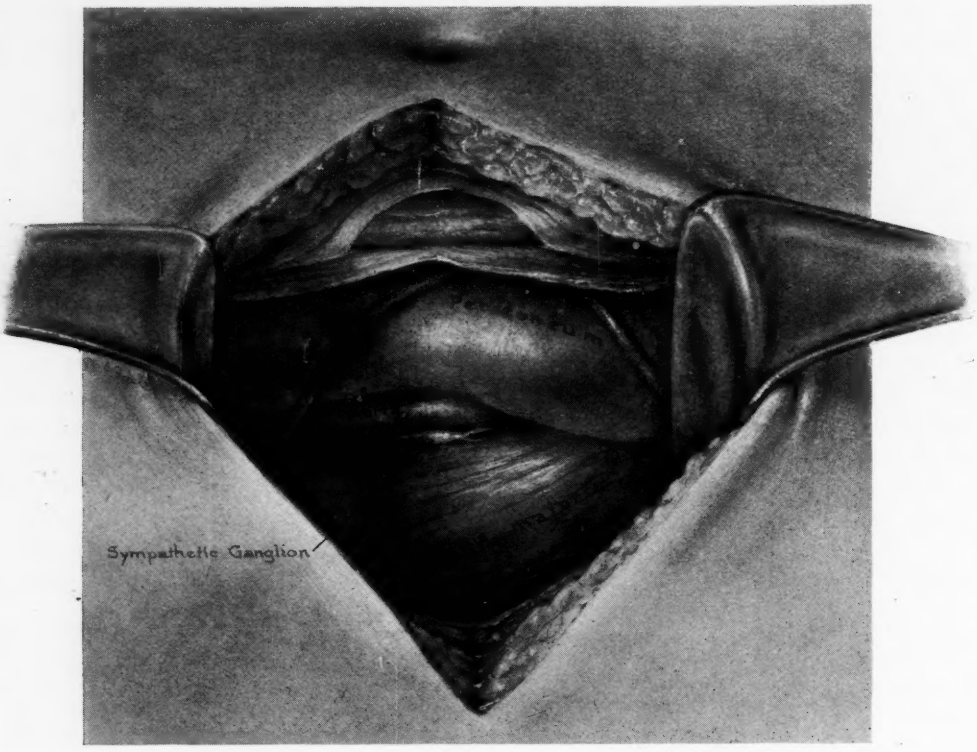

FIG. 289.—Exposure of the umbar sympathetic chain on the inner margin of the psoas muscle.

On the inner margin of the psoas muscle the lumbar trunk is first identified by palpation. It rolls beneath the finger like a firm cord. The fascia over it is opened with scissors, and the trunk caught up on a hook. It is then easy to separate its connections one by one and free it from the point where it emerges between the crura of the diaphragm to the point where it disappears into the pelvis. It is cut off above and below and completely removed. In our experience the simple ramisection still advocated by Royle is less permanent in its results than is complete removal of the chain. Some care must be exercised with the lumbar arteries and veins. If the lumbar sympathetic chain lies in front of the vessels, its removal gives no trouble, but if it lies posterior to them, it must be freed and drawn out from beneath them without sectioning the vessels. If this is done, there will be no trouble from hæmorrhage.

Removal of both lumbar chains at one sitting is quite easily and safely performed by this method.

The wound is then closed in layers, muscle by muscle, care being taken to suture the fascial covering of the muscles rather than the muscles themselves.

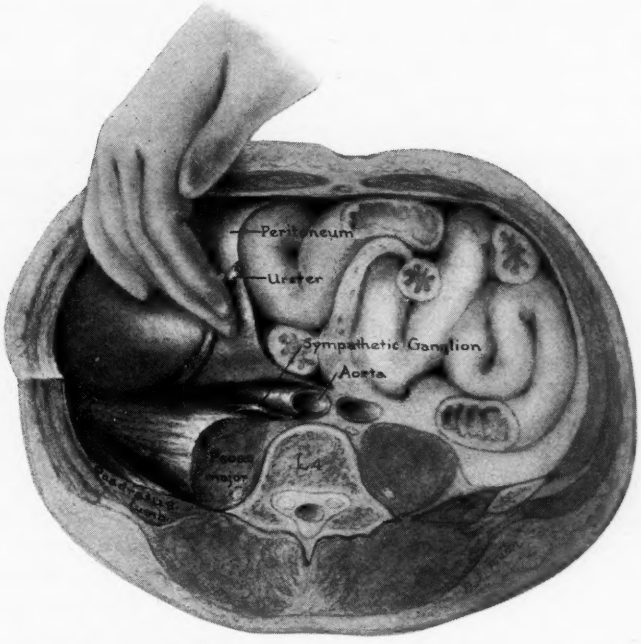

FIG. 290.—A diagrammatic transverse section indicating the approach to the lumbar sympathetic chain.

A very excellent repair of the abdominal wall is thus obtained, and healing occurs without weakness.

Stellate Ganglionectomy.—For the removal of the stellate ganglion, the posterior approach first advocated by Henry[1] is much better than the anterior approach. The technical modification devised by White[2] is excellent and readily permits the removal of both ganglia at one sitting. The illustrations in White's article are confusing because of a most unfortunate typographical error which has separated the titles from the illustrations to which they belong and has placed them beneath illustrations to which they do not refer. By White's transverse incision the operation becomes entirely a muscle-splitting approach and is nearly avascular. Exposure is relatively simple and the stellate ganglia readily removed.

SUMMARY AND CONCLUSIONS

1. Removal of the lumbar sympathetic chain or the stellate ganglion interrupts the vasoconstrictor fibres to the lower and upper extremities respectively and results in profound and lasting increase in blood-flow. Ramisection as distinct from ganglionectomy is less certain and less permanent in its results and should be abandoned in favour of ganglionectomy.

2. The element of vasospasm is present in all of the common vascular diseases

even where the basic pathology of the disease is obliterative. The degree of vasospasm is capable of being determined by temporary block of the sympathetic nerves with novocain.

3. In appropriately selected cases of vascular disease (i.e., those in which a demonstrable degree of vasospasm exists) sympathetic ganglionectomy will result in great improvement in the circulation of the involved extremity. This improvement may be so great as to amount to a symptomatic cure and in any case results in considerable alleviation of the disease.

4. The operations of choice are the transverse abdominal incision for the removal of the lumbar chain and the posterior transverse incision of White for the removal of the stellate ganglia.

My thanks are due to Prof. W. E. Gallie for permission to report these cases from the records of the surgical service of the Toronto General Hospital, and to Dr. J. A. MacFarlane and Dr. D. W. G. Murray who with the author were the surgeons operating upon the cases reported.

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THE PERIPHERAL SYMPATHETIC NERVOUS SYSTEM

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SINCE the surgery of the sympathetic nervous system of necessity consists in the removal of certain portions of it, the problems directly concerning the surgeon can be reduced to two—namely, where best can these excisions be performed, and what results may be expected from such excisions? Three places may be regarded as the ones likely to continue to be chosen: (1) The region of the stellate ganglion; (2) The abdominal sympathetic chain; (3) The hypogastric plexus with or without the inferior mesenteric ganglion. All these procedures interrupt pre-ganglionic fibres, remove ganglion cells, and with these of course the post-ganglionic fibres to which they give origin. From the point of view of the physiological effects interruption or removal of any one of these three would achieve the same results.

The ganglionic regions are chosen because they are places where the sympathetic innervation for considerable regions of the body is gathered into a narrow area, i.e., they may be considered as nodal points, and further the removal of the ganglion cells makes regeneration impossible.

The Stellate Ganglion.—Excision of the stellate ganglion will bring about a sympathetic denervation of the head and face on the corresponding side and cause the mildly unsightly picture of Horner's syndrome from palsy of the unstriped muscle of the orbit—the narrowing of the palpebral fissure, the constriction of the pupil, and the apparent but not real enophthalmos. I have read that some surgeons sensitive to æsthetic considerations have proposed a bilateral operation to get rid of this defect by having both eyes in the same condition.

Effects on the glands of the head and neck region can be ignored, and the absence of sweating and goose flesh are of no importance.

The cardio-accelerators will be interrupted, and again this effect seems to be of no importance to the well-being of the patient. (Some fibres to the thoracic viscera, such as the lungs and œsophagus, will be interrupted.)

The upper extremity will be deprived of its sympathetic innervation. This will affect sweating and the goose-skin reaction, but these can be ignored. The vasoconstrictors to the upper extremity will be interrupted, and this is the important effect that needs further discussion.

The Vasomotor System.—Investigations on the vasomotor system are very difficult because of the many factors involved. There is the physical fact that blood is an incompressible fluid and must go somewhere. There are nervous factors, compensatory factors such as local and general reflexes, the liberation of adrenalin by the suprarenal medulla, and the inherent properties of unstriped muscle.

The effects of the sympathetic system are of two kinds—those which are episodic like the pilomotor or goose-skin reaction and the sweating; and those

which are continuous and tonic. The latter class includes the vasoconstrictor effect.

Concerned in the regulation of blood-pressure there are reflexes which seem purely regulative like the aortic nerve (the depressor) and the carotid nerve (the sinus reflexes—glossopharyngeal), the object of which is to keep the blood-supply to the brain constant. These must be reckoned with in the interpretation of vascular experiments.

The tonic constrictor supply by the sympathetic is the only continuously active pressor system that is known, and if the experimental researches on spinal anæsthesia in dogs are to be trusted, something like 50 per cent of the normal blood-pressure is dependent on these pressor impulses. This fall can be largely counteracted if ephedrine be administered before the spinal anæsthesia is induced. These pressor influences pervade the whole body, with the possible exceptions of the heart, where they exert a dilator effect; the brain, where the constrictor effect is mild or absent; and the lungs, where again the effect is slight if present. The pressor effect includes all the trunk and the abdominal viscera, and again, if the results of anæsthetizing the sympathetic rami as they leave the cord by the ventral roots are reliable, the splanchnic area is not more important than the trunk or limbs from the point of view of the pressor result. That is to say, the older ideas of the splanchnic pool into which all the blood of the body could easily drain have been somewhat exaggerated. It is, I understand, a common observation that surgeons operating with the aid of spinal anæsthesia are not incommoded by any unusual engorgement of the viscera. Further observations on this point by those who have the opportunity would be interesting.

Vasodilators.—Vasodilators are much less well understood. They include some special nerves like the chorda tympani and the cranial parasympathetic in general, the pelvic nerves, or the nervi erigentes or sacral parasympathetics; possibly the ordinary spinal nerves, the antidromic vasodilators (or they may be special vasodilator nerves issuing by the dorsal roots); and finally there is evidence in most parts of the body of some vasodilators which belong to the grey rami of the sympathetic. These, however, are overshadowed by the vasoconstrictor fibres present in these same rami.

The surgical excision, then, removes a portion of this tonic constrictor effect of the sympathetic—an effect which can be shown to be permanent though its maximal dilator level becomes subdued presumably by the tone which is inherent in the unstriped muscle of the blood-vessels. Thus sympathectomy gives us in some degree a permanent vascular dilatation in the denervated area. The application of this result is continually being extended, as, for example, to infantile palsy by Telford and Stopford. It is the only effect that seems to be of any value in the limbs. This statement in regard to pain may need some qualification.

Clearly it becomes of importance to be certain how far the vessels can respond to this release from constrictor tonus. Many ways have been elaborated for doing this, but reference will be made to one only.

For some time we have been studying the peripheral vessels in amputated limbs by means of barium injections and X-ray pictures. This has revealed some interesting points. It discloses in the limbs a whole series of arterial anastomoses amongst the smaller arteries. It gives a picture of the relative density of the arteriolar bed, and shows how enormously richer this is in the plantar region.

It gives in the outline of the vessel wall and in the calibre of the vessels an idea of the nature and distribution of structural changes. Such a method applied in the living would be a means of detecting the presence, the nature, and extent of the structural changes in the vessels, and would thus help to distinguish between spasm and organic disease and also would be of use in determining the level of amputation so that this might be a true elective site and not a rule of thumb. It is clear from the literature that the recent methods of investigation of the circulation in the limbs has encouraged a much more conservative attitude in regard to amputation in general and also of the site at which it may be performed.

Thorotrast is the substance which has been used in the surgical unit at St. Bartholomew's Hospital and some interesting results have been already obtained.

Differences between the Upper and Lower Limbs.—Surgeons have frequently drawn attention to the fact that a sympathectomy for the lower extremity—a lumbar ganglionectomy—is often much more satisfactory than a similar operation for the upper extremity. It has frequently been suggested that the explanation of this lies in anatomical differences of the sympathetic chain, and there has been a tendency to urge the removal of more and more thoracic ganglia as well as of the stellate (inferior cervical ganglion and 1st thoracic ganglion). By various anatomical methods it has been shown that there is a greater abundance of sympathetic fibres to blood-vessels at the distal member of the extremities and these parts have also a greater richness of the arterial bed. These facts explain why angiospasm should be most noticeable in the distal members of the limb. The anæsthetization of nerves reveals that the greatest release from constrictor tonus occurs in the hands and feet, and the same method also shows that the foot increases its temperature to almost twice that of the hand. This suggests that the degree of constrictor tonus is much higher in the lower extremity than in the upper. Further evidence of this increased constrictor tonus is shown in the fact that a person lying horizontal in a warm room will show peripheral skin temperatures highest in the face region, next highest in the upper extremity, and lowest in the feet. If the legs are plunged into hot water, the upper limbs will quickly show an increased skin temperature, while the reverse experiment—plunging the arms into hot water—takes a very much longer time to increase the temperature of the legs, and sometimes the effect of the warming does not appear in the legs.

It is clear that the upright posture demands an increased constrictor tonus in the lower extremity if the effects of gravity are to be counteracted.

Thus I think the better expectations of a good result from sympathectomy in the lower extremity are to be explained by the higher constrictor tonus of this extremity.

The Viscera.—For surgical purposes one acts on the general law that the sympathetic inhibits the onward peristaltic wave of the viscera and at the same time increases the activity of the sphincters, the vagus and the pelvic nerves having the opposite effects. This is an over-simplification of the problem, for the results of all animal experiments concur in suggesting that the antagonism between the two systems is nothing like so sharp, that both systems can sometimes act either as augmentors or inhibitors, and that the action which occurs depends on the tonus of the gut muscle at the moment of the inquiry, and this tonus depends

perhaps on the intrinsic nerves of the gut which extend from the lower œsophagus to the rectum, and on other factors not yet elucidated.

In the present state of knowledge it is not profitable to discuss this matter further, but it must be remembered by the surgeon that the issue of sympathectomy in the viscera is not by any means clear-cut.

The Œsophagus.—The œsophagus contains much striate muscle and there is agreement about the importance of the extrinsic nerves and the medullary centre for deglutition.

The lower third is non-striate, possesses an intrinsic nerve plexus, participates in the movements of the stomach such as those of hunger contractions, and varies

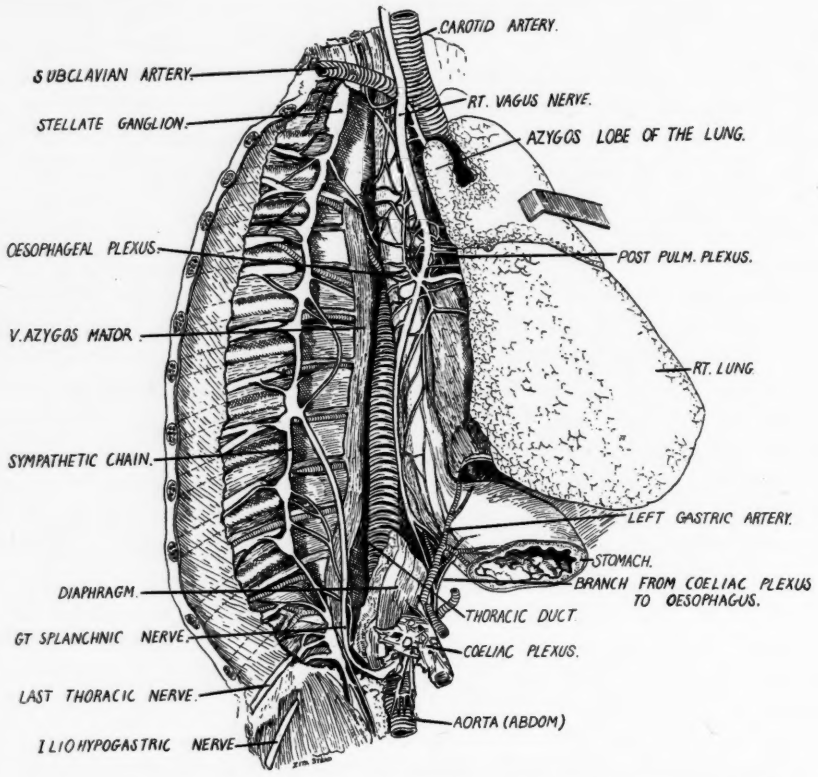

FIG. 291.—Dissection of the nerves to the œsophagus in a human fœtus. Right side.

much in tonus, being closed when the stomach is full and relaxed when the stomach is empty. Augmentor and inhibitor fibres have been found in both the vagus and sympathetic.

The vagal plexus closely invests the lower two-thirds of the œsophagus and numerous twigs from this plexus can be seen to enter its muscular walls. Slender sympathetic filaments from the inferior cervical and thoracic sympathetic ganglia travel alongside the intercostal vessels, but they are too small and delicate to trace beyond the front of the vertebral column and the aorta. It seems unlikely that the œsophagus receives other than a very scanty sympathetic supply directly from the adjacent ganglia (*Figs.* 291, 292).

Sympathetic fibres, however, do reach the œsophagus from above, having entered the vagi from the cervical sympathetic chain. The other route by which sympathetic fibres may reach the region of the cardia is by way of the cœliac plexus, from which they may travel in company with the left gastric artery. The sympathetic fibres which come from above could be conveniently interrupted by removal of the stellate ganglion.

Knight, in his experimental work on cats, was led to emphasize the importance of this cœliac contribution as inhibitor of the cardiac sphincter and suggested its removal for cardiospasm.

The Colon.—For our knowledge of the neurosurgery of the colon and bladder we are mainly indebted to Professor Learmonth. He has suggested that the

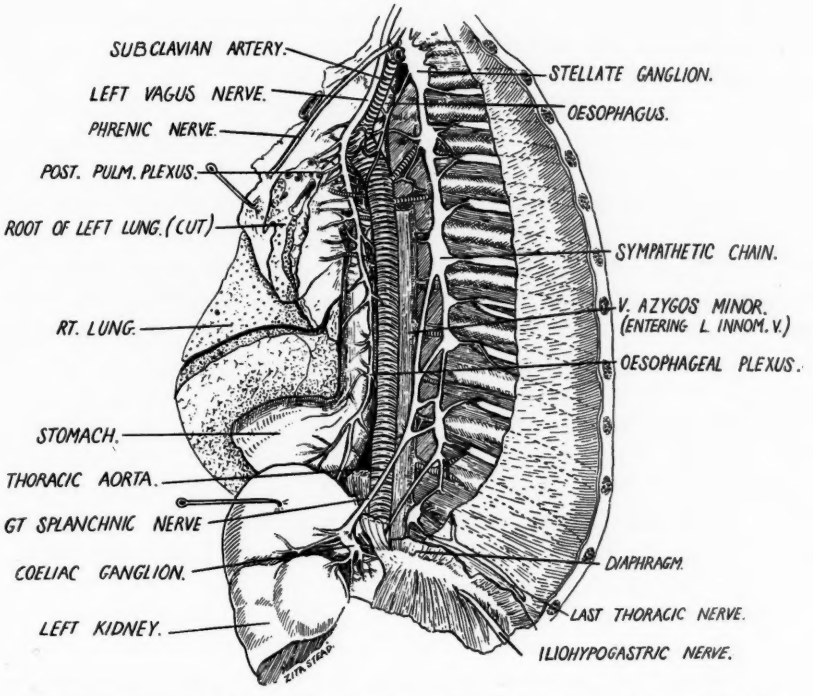

FIG. 292.—Dissection of the nerves to the œsophagus in a human fœtus. Left side.

association of bladder disturbances with megacolon implies that this common embryological unit innervated from the same neural sources must be reacting to some common underlying cause.

It should be pointed out, as Learmonth has done in his papers, that the internal generative organs receive their nerves from the hypogastric plexus, and that, despite many suggestions to the contrary, no clear evidence has been produced that these organs receive any parasympathetic fibres. Their glandular activity and muscular contractions are activated through the sympathetic, and when denervated, as they are by removal of the hypogastric plexus, in the male at any rate the seminal fluid becomes imperfect and sterility may follow.

The Kidney and Ureters.—The kidney may perhaps receive some fibres from the vagus. If it does, no evidence has been obtained that they have any

function. It is supplied by efferent sympathetic fibres which proceed along the renal vessels from the renal ganglion and from the adjacent aortic plexus. These sympathetic fibres are apparently purely vasomotor in function. No clear evidence has been obtained of secretory fibres, and the temporary diuresis that follows a sympathectomy is best explained as the result of vasodilatation.

The movements of the ureter are poorly understood. Unlike the case of the œsophagus the evidence for nervous regulation has hitherto been regarded as very slight. Both peristalsis and anti-peristalsis are easily elicited by direct stimulation. The nerves are derived from the renal plexus and from the spermatic plexus, but these contributions seem extremely scanty. To the lower portion of the ureter they come from the hypogastric and from the pelvic nerves, and these seem abundant. Just as the œsophagus gives the impression of carrying its nerves downwards with it, so the ureter gives the impression of carrying its nerves upwards with it.

To the idea that the ureteric movements were myogenic in origin it has been added that the control of its lower end was purely mechanical owing to its oblique course through the bladder musculature. However, Learmonth has brought the first convincing evidence that its lower end is strongly contracted by stimulating the hypogastric nerve. Hence it falls into line with the behaviour of the colon, and removal of the hypogastrics should help in the condition of the megalo-ureter.

The Distribution of the Pelvic Nerve.—It has always been a problem to what extent the colon is innervated by the pelvic parasympathetic nerves. If, as most physiology text-books suggest, the vagus ceases at the ileocolic sphincter, then it might be supposed that the innervation of the whole of the colon came via the pelvic parasympathetic nerves (pelvic nerves). It would seem almost an anatomical impossibility that this should be so. If the vagus be taken as far as the splenic flexure, the difficulty, though less, is still great. The belief that the pelvic parasympathetics do reach the colon depends on the effects of stimulation, for then a contraction of the rectum and the colon occurs. How much of the colon contracts is not clear. It has been suggested by some anatomists that the pelvic nerve-fibres get to the colon by ascending in the hypogastric plexus, and if this is so, then removal of the hypogastric plexus should denervate the bowel and this should invalidate the good effects of sympathectomy for megalocolon. Anatomical work done by Mitchell at the suggestion of Learmonth does not support such a contention. My own dissections are in agreement with Mitchell and do show some fibres which appear to ascend from the pelvic nerves, but the largest of these pass upwards near to, but not actually in contact with, the superior hæmorrhoidal artery, and if they are pelvic fibres they would not be included in the removal of the hypogastric plexus. Division of the pelvic nerve in the cat shows no degenerated fibres in the hypogastric nerves. (*Fig.* 293.)

It is of interest that evacuation of the bowel occurs after spinal anæsthesia. Since the sympathetic system and pelvic nerves are out of action, it may be inferred that the vagus alone is operative.

At the moment I am inclined to follow the French anatomists who would extend the influence of the vagus as far as the limit of the colon and confine the pelvic nerve to the pelvis. In fact they call it the ano-perineal nerve. It seems at present that we may ignore the possibility of denervating the colon entirely by removal of the hypogastric plexus.

Afferent Fibres.—There is still in my opinion no reason for departing from the statement of Langley that the afferent fibres which run with the sympathetic system are visceral afferents coming from dorsal roots and spinal ganglia like sensory nerves.

Despite some suggestions to the contrary, there is no reason to suppose that the rami to the limbs or the cervical sympathetic chain contain any afferent fibres. Blood-vessels in the limbs receive an abundant sensory supply, but anatomy and experiment show that these are fed to the vessels from the adjacent nerves. The alleviation of some kinds of pain by sympathectomy are not to be explained at all by interruption of afferent fibres. The explanation of the good results reported is unknown to me.

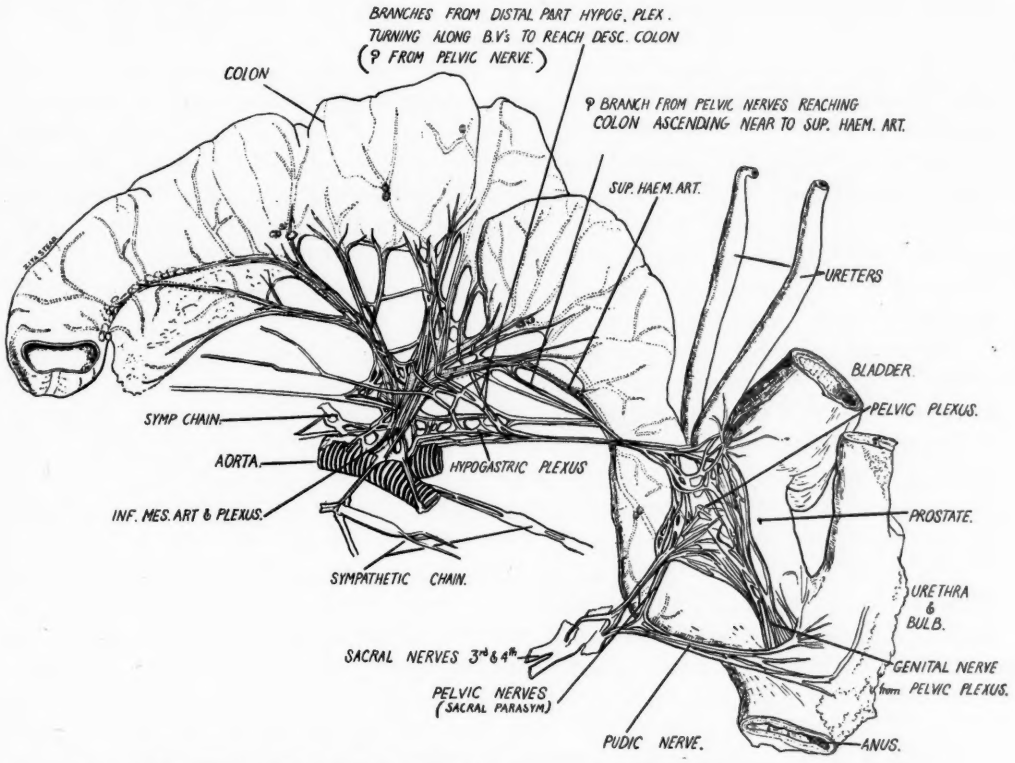

FIG. 293.—Dissection of the inferior mesenteric, hypogastric, and pelvic nerves in a human fœtus. The apparent ascending course of branches of the pelvic nerves is indicated.

In the case of the viscera the afferents do run with the sympathetic fibres. They enter the white rami, connect with the spinal ganglia, and enter the cord by the dorsal roots.

For the heart the upper four dorsal roots and ganglia furnish the pathway of cardiac afferents. They can be interrupted at the stellate ganglion, at the spinal ganglia, or in the roots. Cardiologists are coming more and more to regard the pain in angina as the symptom to be relieved, and if the pain can be abolished such patients go on very well for a long time. It is not so much a danger signal as a thing to be got rid of. If this is so, it is clear some form of surgical section or injection is indicated if drugs fail.

The great splanchnic contains a large number of afferents and is the highway of sensory impulses from the viscera of the upper abdomen. The kidney receives its afferent fibres via the lesser splanchnic, which, according to some observers, is an entirely afferent nerve. Afferent endings are known anatomically in the perinephric tissues, in the capsule of the kidney, in the renal sinus, and about the pelvis. Renal pain in hydronephrosis of non-obstructive origin should be alleviated by injection or section of the lesser splanchnic.

The hypogastric plexus conducts many afferent fibres from the pelvic viscera and this fact has been made use of for the alleviation of a variety of painful affections of the pelvic viscera. The pelvic nerve also contains a large number of afferent fibres, but these subserve so many important reflex functions that even if they were accessible they are better left alone.

It would not be proper to end these few observations without referring to the brilliant work recently accomplished at the Medical Research Institute by Sir Henry Dale and his co-workers. Their results abolish the terms used in the course of my remarks—indeed, they abolish the very title of the paper, for it is now known certainly that a portion of the cerebrospinal nervous system and the whole of the autonomic nervous system achieve their effects through the intermediation of chemical substances. These substances normally formed in the body are acetyl-choline and adrenalin. Thus there are two kinds of nerves which are to be called cholinergic and adrenergic :—

The cholinergic system includes : (1) The pre-ganglionic and post-ganglionic fibres of the parasympathetic system ; (2) The pre-ganglionic system of the sympathetic ; (3) Some post-ganglionic fibres of the sympathetic system such as the fibres of the sweat glands, possibly the vasodilators, and some of the fibres to the gut ; (4) The ordinary motor fibres to the striate muscles.

The adrenergic fibres comprise the remaining post-ganglionic fibres of the sympathetic nervous system.

This grouping cuts right across the existing classification. Already this discovery of the chemical intermediation of nervous processes has cleared up the difficulty about sweating, always anomalous in its pharmacology. Doubtless it will make clear much of the contradictory actions of the autonomic fibre on the gut muscle and sphincters.

I wish to thank Miss Stead, of the Anatomy Department, St. Bartholomew's Hospital, for making the accurate drawings which illustrate this paper.

THE RESULTS OF SYMPATHECTOMY

AN ANALYSIS OF THE CASES REPORTED BY FELLOWS OF THE ASSOCIATION OF SURGEONS *

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THE Association of Surgeons is greatly indebted to those Fellows who submitted their case records for analysis, but it is regrettable that the total number of these records is less than 250, and that nearly half the cases have been reported on within a year of operation. Only about a quarter of the cases have been followed up for long enough to show the *late* results of sympathectomy, and in order to make this matter as clear as possible the analysis has been made so as to indicate the results at stated periods after operation.

I. DISORDERS OF THE CIRCULATION

1. Sympathetic Ganglionectomy for Raynaud's Disease.—

Severity of the Disease.—When the clinical notes of the cases of Raynaud's disease were scrutinized it soon became apparent that they fell into three groups according to their severity, and that, at all events in the upper extremity, the result of operation varied with the severity of the disease. In the mildest cases exposure to cold gave rise to uncomplicated attacks of cyanosis, but when the disease was moderately severe shallow ulceration of the finger-tips occurred and pain was a more prominent feature, being severe enough in many cases to interfere with the patient's occupation. The most serious complication, however, was scleroderma, for those who manifested this condition suffered not only from extremely frequent and painful attacks induced by cold and accompanied by ulceration of the finger-tips, but the skin of their fingers became so tightly stretched and stiff that serious crippling resulted in many instances.

Sex Incidence.—Of 41 patients in whom the hands were affected 37 were women, and though the female preponderance was not so well marked when the feet were involved, only 4 of the 20 reported cases were males.

Operation.—Peri-arterial neurectomy is not considered a suitable procedure for the treatment of Raynaud's disease, and only those cases in which there was satisfactory evidence that the inferior cervical and upper two thoracic ganglia, or the 2nd, 3rd, and 4th lumbar ganglia, had been excised were accepted for analysis. The operation results are summarized in *Table I.*

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* Delivered to the Meeting of the Association of Surgeons of Great Britain and Ireland, May 3, 1935.

Table I.—RESULTS OF GANGLIONECTOMY IN RAYNAUD'S DISEASE

PART AFFECTED	SEVERITY OF DISEASE	NUMBER OF CASES	FOLLOWED UP FOR								
			1 Year			2 Years			Over 2 Years		
			Success	Improvement	Failure	Success	Improvement	Failure	Success	Improvement	Failure
Hands	Uncomplicated attacks	21	13			4			4		
	Complicated by ulceration ..	9	4	1		2	1		1		
	Complicated by scleroderma	11			3	1				2	5
Feet	Uncomplicated attacks	18	3			7			8		
	Complicated by ulceration ..	2								1	1
	Complicated by scleroderma	0									

The result has been expressed as 'success', 'improvement', or 'failure', but it is necessary to define more accurately what these terms imply. By success must be understood a great diminution in the frequency and severity of attacks, but not complete absence of attacks. In all cases conforming to the accepted criteria of Raynaud's disease exposure to cold gave rise to cyanosis even after sympathectomy. Recurrences have been observed particularly in the hands, and if the cyanosis was less easily induced and was unaccompanied by pain, the operation has been regarded as successful.

A few cases could not be regarded as successful because ulceration had recurred after operation, but since pain had been abolished the result has been considered an improvement. Patients in this group who before operation were prevented by pain from carrying out even the simplest household duties were subsequently able to undertake work involving exposure to fairly intense cold without suffering for it.

When pain, which was usually distressingly severe, accompanied the recurrence of cyanosis and ulceration the patients were unable to work, they were obliged to protect their hands from exposure even to moderate chilling, and the operation

had not only failed to ameliorate their symptoms but seemed in some cases to have aggravated their discomfort.

Table I shows that operation was successful in all the mild cases of Raynaud's disease and in the majority of those complicated by ulceration, but that when the disease was present in the severe form accompanied by scleroderma sympathectomy was a complete failure in 8 out of 11 cases. It is remarkable that the changes characteristic of scleroderma were not present in the feet in any of the cases treated by lumbar ganglionectomy, and this feature may be of significance in accounting for the more favourable results of lumbar as compared with cervico-thoracic ganglionectomy for Raynaud's disease.

2. Sympathetic Ganglionectomy for Obliterative Arteritis.—

a. Thrombo-angiitis Obliterans.—Here again it seemed that the cases could be grouped according to their severity into those in which intermittent claudication was the only prominent symptom, those in which pain was present at rest as well as after exercise, and those complicated by gangrene of the toes.

As regards the incidence of the disease it is noteworthy that out of 69 patients no fewer than 66 were men; and only 3 operations were performed for manifestations of the disease in the upper extremities.

The results of lumbar ganglionectomy in 66 cases of thrombo-angiitis obliterans are given in *Table II*, which includes 46 cases operated upon and followed up by Professor E. D. Telford, to whom we are indebted for valuable assistance and advice.

Table II.—Results of Ganglionectomy in Thrombo-angiitis Obliterans

Severity of Disease	Number of Cases	Result					
		Claudication		Rest-pain		Gangrene	
		Diminished	Persisting	Relieved	Persisting	Arrested	Major Amputation
Claudication only	29	19	10				
Complicated by rest-pain ..	15			12	3		
Complicated by gangrene of toes	22					14	8

Table II confirms the prevalent impression that intermittent claudication is a symptom which is difficult to relieve by operation. Rest-pain, however, and early gangrene often respond to ganglionectomy in a manner which is most gratifying considering that the disease tends to be progressive, and that high amputation is frequently the only alternative method of treatment. When gangrene of a toe is established sympathectomy may be regarded as successful if the patient loses his toe instead of losing his leg.

The study of these cases has failed to indicate any clinical features by which one can forecast the result of operation. The response of the skin temperature

to spinal anæsthesia is sometimes helpful, but a poor response must not be regarded as a clear contra-indication to ganglionectomy. It may be that further experience with arteriography will point the way to the solution of the problem.

The beneficial effects of sympathectomy seem to depend upon the possibility of improvement in the peripheral circulation resulting from dilatation of vessels as yet unaffected by the disease, and it is questionable whether the pathological process itself is retarded by the operation. There is no doubt, however, that serious complications of the disease can appear very shortly after operation, and in at least two of the reported cases amputation had to be undertaken because of thrombosis of the diseased popliteal artery, which took place within a week of the patient's discharge from hospital, and well within the period during which the post-operative vasodilatation might be expected to be fully developed.

The 3 patients who suffered from thrombo-angiitis obliterans involving the arms were treated by cervico-thoracic ganglionectomy, the operation being successful in 2, but a complete failure in the third.

b. Other Forms of Obliterative Arteritis.—Lumbar ganglionectomy proved to be of no value in one case of syphilitic endarteritis. Three cases were reported in which lumbar ganglionectomy was performed for senile arteriosclerosis. One patient obtained relief from rest-pain, and in the other two, though amputation became inevitable, the legs were taken off below the knee and the stumps healed well.

There were no cases of diabetic gangrene treated by ganglionectomy; reference will be made later to the value of peri-arterial neurectomy in senile and diabetic gangrene.

3. Sympathetic Ganglionectomy for the Circulatory Disorders following Infantile Paralysis.—One case was reported in which cervico-thoracic ganglionectomy had been performed without success for ulceration of the hand following infantile paralysis, whereas there were 26 cases of impaired circulation in the legs treated by lumbar ganglionectomy.

Table III.—Results of Ganglionectomy for the Circulatory Disorders following Infantile Paralysis

Severity of Disease	Number of Cases	Followed Up For								
		1 Year			2 Years			Over 2 Years		
		Success	Improvement	Failure	Success	Improvement	Failure	Success	Improvement	Failure
Legs cold and blue ..	9	5		1	3					
Legs cold, blue and ulcerated	17	7	1	1	2	1	1	4		

It is stated that in acute anterior poliomyelitis males and females are attacked with equal frequency, and it is therefore interesting to find that in this series

there were nearly four times as many girls as boys suffering from cold blue legs as a late complication of the disease. Furthermore the circulatory phenomena observed were as a rule less severe in the males than in the females.

In *Table III* the cases have been divided into those in which the affected limb was merely cold and cyanosed, and those in which the presence of ulceration indicated a more severe degree of circulatory embarrassment. The results were distinctly encouraging, both the colour and the temperature of the affected limbs being restored nearly to the normal state, and on the whole they were better in the cases without ulceration. The only failure in the milder group occurred in a girl of 19 whose leg had to be amputated for pain less than a year after lumbar ganglionectomy had been performed in the hope of relieving this symptom.

In the group with ulceration of the legs 13 were successfully treated; 2 operations resulted in improvement, the 'chilblains' being much less severe though still present; and 2 were failures, with persistent ulceration in one case, and pain necessitating amputation in the other.

One instructive case was reported in which lumbar ganglionectomy had been performed for 'trophic' ulceration of the leg complicating spina bifida. The ulcers were situated on an anæsthetic area of skin, and the operation had no effect upon them.

4. Lumbar Ganglionectomy for Erythrocyanosis Frigida.—This condition affecting the legs of young women was also divisible into two groups, one in which the skin showed only the characteristic patches of mottled red and blue discoloration, and the other in which ulceration had supervened. The results of operation are shown in *Table IV*.

Table IV.—Results of Ganglionectomy in Erythrocyanosis Frigida

Severity of Disease	Number of Cases	Followed Up For					
		1 Year		2 Years		Over 2 Years	
		Success	Failure	Success	Failure	Success	Failure
Legs cold and blue	10	1		4		5	
Legs cold, blue, and ulcerated	4	2			2		

After operation the legs became warm and pink in all the uncomplicated cases, but 2 of those with ulcers suffered from recurrent ulceration, though there were no signs of restoration of function in the structures supplied by the sympathetic.

The thickening of the tissues which is often associated with erythrocyanosis frigida and is commonly referred to as 'œdema' was noted to be diminished after operation, but, though the subcutaneous tissue may have felt softer, the limb seldom recovered its natural shape.

II. DISORDERS OF THE COLON

1. Sympathectomy for Idiopathic Dilatation of the Colon (*Hirschsprung's Disease*).—The most striking feature in the reports of these cases was the variety of operations undertaken for its relief, which indicates the lack of agreement as to the best method of blocking sympathetic impulses to the bowel without damage to the parasympathetic supply. There were 29 cases reported in children, and as constipation and distension of the abdomen had been present since birth, the term 'congenital megacolon' would be a suitable synonym for this group.

Sex Incidence.—It is noteworthy that of the 29 patients 17 were boys, and since this sex incidence presents a striking contrast to that of intestinal stasis in adults, in which there is a well-marked female preponderance, it is an argument against the view that stasis in adults is merely a late manifestation of a defect which has been present in a latent form since childhood.

Table V.—Results of Operation in Hirschsprung's Disease

Operation	Number of Cases	Followed Up For								
		1 Year			2 Years			Over 2 Years		
		Success	Improvement	Failure	Success	Improvement	Failure	Success	Improvement	Failure
Inferior mesenteric and presacral neurectomy	17	8	1		4			3	1	
Bilateral lumbar ganglionectomy	9		1	1	1	2		4		
Left lumbar ganglionectomy	2		1		1					
Presacral neurectomy	1		1							

The results of operation are shown in *Table V*. Seeing that before operation none of these children had ever had a spontaneous action of the bowels, most of them required enemata at regular intervals, and many had suffered from repeated attacks of fæcal impaction with complete intestinal obstruction, the success achieved in 21 out of the 29 cases was dramatic. Enemata were never required, and, though an aperient might have to be given occasionally, the bowels acted as a rule without help. The general condition of the patients showed a remarkable improvement, which was especially noticeable in their colour, growth, nutrition, and energy.

In the 7 cases in which the operation result is described as 'improvement' aperients were required more frequently, but in only 1 was an occasional enema necessary to keep the bowel clear. The only case in which the operation was a

failure was complicated by severe general debility, and the patient died three months after operation without having shown any sign of improvement.

2. Sympathectomy for Acquired Intestinal Stasis.—There were 15 cases in this group, and of these 13 were females. The indications for operation seemed to be less clearly defined than in children, and the records did not mention the performance of any pre-operative tests to determine the cases suitable for sympathectomy. The results of operation are shown in *Table VI.*

Table VI.—Results of Sympathectomy in Acquired Intestinal Stasis

Operation	Number of Cases	Followed Up For								
		1 Year			2 Years			Over 2 Years		
		Success	Improvement	Failure	Success	Improvement	Failure	Success	Improvement	Failure
Inferior mesenteric and presacral neurectomy	12	2	1	5	1	2	1			
Bilateral lumbar ganglionectomy	2					1		1		
Presacral neurectomy	1			1						

Of 15 operations 7 ended in failure, the state of the patients 'improved' by operation was less satisfactory than that of the corresponding Hirschsprung group, and there seemed to be a tendency to relapse into severe constipation after an initial period of more regular action of the bowel.

From a comparative study of the Hirschsprung group in children and acquired stasis in adults one formed the impression that dilatation of the bowel was a prominent feature in the cases which responded well to sympathectomy, whereas when mere stasis was present without any considerable dilatation sympathectomy was less likely to succeed.

Bladder Involvement.—Infrequent micturition with over-distension of the bladder and a tendency to retention of urine was associated with constipation in 4 of the reported cases of Hirschsprung's disease, and in 3 cases of acquired intestinal stasis. Detailed information was insufficient to make a reliable estimate of the effect of the operation upon the bladder, but there is no doubt that in some instances normal micturition was established, the patients being conscious of a change in bladder function immediately after operation.

III. SYMPATHECTOMY FOR PAIN

1. Renal Pain.—The report on the treatment of renal pain is of value because so many of the patients were examined by a uniform method before and after operation by Mr. J. Bagot Oldham. The selection of cases suitable for sympathectomy involved a careful preliminary investigation, and pain was not

accepted as renal unless a characteristic attack could be induced by distending the renal pelvis with fluid injected through a ureteric catheter. In several cases there was considerable delay in the appearance of dye from the affected side on chromocystoscopy, indicating abnormal function of the renal pelvis or ureter, though the common painful diseases of these structures could be excluded.

The operation performed in every case was peri-arterial neurectomy of the renal artery, and in some the stripped artery was painted with 10 per cent phenol. The results of operation are shown in *Table VII*.

Table VII.—Results of Operation for Renal Pain

Group	Number of Cases	Followed Up For					
		1 Year		2 Years		Over 2 Years	
		Success	Failure	Success	Failure	Success	Failure
Renal pain ..	11	4	1	3		3	
Renal pain with hydronephrosis	8	1		2		5	
Renal pain with nephroptosis ..	7	2	2	1		2	

In the successful cases relief was obtained after an initial period of forty-eight hours during which there was an exacerbation of the pain, and the secretion of urine was diminished. Later, however, the denervated kidney secreted an abnormally large quantity of dilute urine, and dye appeared in the bladder in the normal time in cases which had previously shown delayed excretion. The renal pelvis could be distended with large quantities of fluid without pain.

Table VII shows that in certain cases pain was accompanied by hydronephrosis or nephroptosis, whereas in others it was the only prominent feature; and further that the failures were manifest within a short period after operation. One of the failures was a case which presented unusual difficulty in diagnosis, and the patient died of acute dilatation of the stomach after an operation in which both the gall-bladder and the right kidney were explored. Both the other failures resulted from erroneous diagnosis, for in the one case the complaint of pain was still made although over-distension of the renal pelvis was painless, and in the other pain persisted even after nephrectomy.

2. Causalgia.—The investigation included 9 cases of causalgia following peripheral nerve injury in which the characteristic pain persisted in spite of repeated attempts to relieve it by local operations on the damaged nerve. It must be understood that any removable local stimulus had been dealt with before sympathetic ganglionectomy was undertaken.

In 8 cases the hand was involved, and the only case reported of causalgia in the lower extremity occurred in a below-knee amputation stump, the patient being a war pensioner: 5 out of the 9 patients were men. The results of operation are shown in *Table VIII*.

The relief of pain in the majority of cases was remarkable. 'Improvement' signifies abolition of irradiated pain and vasomotor disturbances, but hyperæsthesia remained over an area of skin surrounding the original wound. Sympathectomy failed to give relief in one case, and when the arm was amputated for persistent pain the median nerve was found to be adherent to the original scar.

Table VIII.—Results of Operation for Causalgia

Part Affected	Number of Cases	Followed Up For								
		1 Year			2 Years			Over 2 Years		
		Success	Improvement	Failure	Success	Improvement	Failure	Success	Improvement	Failure
Hand	8	3		1				3	1	
Leg ..	1	1								

The leg case was noteworthy because the man had suffered from an ulcerated hyperæsthetic amputation stump for twelve years and had never been able to wear an artificial limb. Pain disappeared immediately after lumbar ganglionectomy, the nutrition of the stump was greatly improved, and within a few weeks the patient was able to walk on an artificial limb.

The most suitable cases for sympathectomy seemed to be those in which the pain was accompanied by vasomotor phenomena such as cyanosis and flushing of the skin, over-sensitivity to changes in temperature, and excessive secretion of sweat, and in which any gross local cause of nerve irritation had been removed.

IV. MISCELLANEOUS CONDITIONS

In addition to the larger groups there were several small groups and some isolated cases which deserve notice.

Chronic Arthritis.—Sympathetic ganglionectomy was performed in 5 cases of chronic arthritis associated with excessive sweating and vasomotor disorders in the affected limb. In 3 patients the arm joints were involved, and 2 of them derived great benefit from the operation. In the other 2 patients arthritis affected the lower limb, and in 1 of them the treatment was successful in relieving pain and restoring function.

Hyperidrosis.—This was successfully treated by sympathetic ganglionectomy in 2 patients, one being a woman who suffered from excessive sweating of the hands, and the other a man the skin of whose feet became so sodden with sweat that he was unable to walk to work. After lumbar ganglionectomy the skin was rapidly restored to its normal texture, he was soon able to resume his normal activities, and he had remained well till the time of reporting two years after operation.

Retinitis Pigmentosa.—Seven cases of this condition were treated by superior cervical ganglionectomy. No improvement occurred in 5; the progress of the disease seemed to be arrested in 1; and in 1 case there appeared to be slight improvement.

Spasmodic Dysmenorrhœa.—Presacral neurectomy for spasmodic dysmenorrhœa had been performed twice, one of the operations being successful; but this treatment failed to give relief in a case of congestive dysmenorrhœa.

Sympathetic ganglionectomy failed to improve the condition of two children suffering from spastic diplegia; and the operation was also a failure in a case of post-encephalitic palsy.

Histological Reports on the Sympathetic Ganglia Excised.—Most of the reports stated that sections of the tissue excised showed normal sympathetic nerve-cells and fibres. Degeneration of the ganglion cells, fibrosis, and lymphocytic infiltration of the interstitial tissue were noted as abnormalities by a few pathologists. Since these features were found in ganglia removed in the treatment of various diseases, even when there was no reason to suppose that the sympathetic system was at fault, it is probable that the changes regarded as evidence of disease in the ganglia were in reality variations in the microscopic characters of healthy ganglionic tissue.

Recovery of Function in Denervated Organs.—When accurate temperature records had been made it was found that limbs tended to cool in the course of some months as the effect of the extreme post-operative vasodilatation was passing off. Patients with Raynaud's disease, even those who had been greatly benefited, said they wished their hands had remained as warm as they had been for the first six months after operation.

Horner's syndrome was observed to become less marked in the course of time, especially in the younger patients, but it never disappeared.

Recovery of sweating was noted very seldom, and when it was observed there was some doubt about the completeness of the sympathectomy. The tendency towards vasoconstriction was noted repeatedly in limbs over which sweating was completely absent, and it is unlikely that the restoration of function in the muscle coat of the arteries indicates regeneration of the severed sympathetic nerves. It is more probable that recovery of function means the acquisition of independent activity, and all the evidence seems to favour the view that the sympathetic system is a regulator of function, and not a prime mover as is the cerebrospinal motor system.

Disabilities following Sympathectomy.—After cervico-thoracic ganglionectomy the disabilities were only temporary in most cases, though a few patients complained that as a permanent result of the operation the skin of the hands had become so dry that it cracked, and roughness of its surface interfered with delicate work such as fine sewing. Within a week of the operation a large number of patients began to suffer from pain in the shoulders and arms, which commonly persisted for about six weeks and then gradually passed off. A few complained of weakness of the eyes which required correction by glasses, and there were a few cases in which stuffiness of the nose was troublesome for a few weeks. Excessive sweating over the trunk was an annoyance to some patients,

and seemed to be rather more likely to occur when the lumbar trunk also had been excised.

After presacral neurectomy male patients, though still potent, became sterile owing to interference with the sympathetic supply to the seminal vesicles and to the bladder neck, and a similar effect was noticed in some cases of bilateral lumbar ganglionectomy, presumably when visceral branches going to the hypogastric plexus originated from the excised portions of the lumbar ganglionated trunks. There seemed to be some evidence that, at all events after lumbar ganglionectomy, sterility might not be permanent.

V. PERI-ARTERIAL NEURECTOMY

It has become fashionable to say that peri-arterial neurectomy should have no place in surgery. This attitude has been adopted largely because of our inability to produce any scientific justification for the operation, but there is no doubt of its practical value in the treatment of indolent ulcers, and in alleviating the pain and limiting the extent of gangrene of the extremities.

Reports were made of 32 cases in which peri-arterial neurectomy had been performed, and the results obtained in 20 cases of gangrene deserve special mention. There were 14 cases of senile gangrene, all occurring in males, and involving the left foot in 10 cases. Peri-arterial neurectomy of the femoral artery relieved the pain in 8 cases, the spread of gangrene was arrested in 7, and in only 7 cases was a major amputation required.

Six cases of diabetic gangrene were reported, the sexes being equally represented. As in the senile variety, the left side was more commonly affected, gangrene occurring in the left foot in 5 out of the 6 cases. Pain was relieved after peri-arterial neurectomy of the femoral artery in every case, the gangrenous process was arrested in 4, and in only 2 was a major amputation necessary. Whatever the explanation may be, there seems to be no doubt that this operation is of real value as a palliative measure in this painful complaint when the only alternative treatment is amputation.

CONCLUSION

Except in certain of the cases in which sympathectomy is carried out for pain, it is not correct to say that any of the operations under consideration can 'cure' a patient. These excisions of sympathetic nerves and ganglia have been designed not to extirpate diseased structures, but to rectify disorders of function in organs whose activity is controlled by sympathetic impulses. The results here recorded are of value in so far as they indicate the particular conditions in which this object may be achieved.

CENTRAL CONTROL OF THE SYMPATHETIC NERVOUS SYSTEM

By JOHN BEATTIE

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EXPERIMENTAL work during the past fifteen years has shown that phenomena similar to those elicited by stimulation of sympathetic and parasympathetic nerves can be obtained by appropriate stimulation of a region of the brain forming the lateral walls and floor of the third ventricle. This region is known as the hypothalamus.

Detailed anatomical studies of this region in mammals, including man, have resulted in the plotting out of well-defined cell groups. These masses of nerve-cells lie in three zones—a mass which lies close to the ependymal lining of the ventricle, several masses lateral to the sub-ependymal group forming the intermediate zone, and a still more lateral mass of cells forming the so-called lateral hypothalamic zone in which there is no clear definition of cell groups. Still more lateral to the lateral hypothalamus are found the medial nuclei of the thalamus.

The differentiation of the cell groups in the sub-ependymal and intermediate zones varies considerably in different species. In a like manner there are considerable differences in the size of the various groups. Whatever the significance of these observations may be, it is quite unknown at present.

A study of the fibre connections of the various cell masses gives some clue to their probable functional significance. Speaking broadly, the cell groups in relation to the optic chiasma, i.e., in the more anterior part of the hypothalamus, send fibres into the hypophysial stalk and thence into the posterior and intermediate lobes of the pituitary body. Numerous fibres are also given off which are seen to pass posteriorly in a dense felt-work of fibres towards the brain-stem, where at least some of them end in the upper medulla. The cell groups which lie close under the ependyma send axons into the same system of descending fibres. These sub-ependymal nerve-cells lie close to a very specialized part of the ependymal epithelium, which, as several workers have suggested, may have either a secretory or an absorptive function. More posteriorly and lying dorsal to the mamillary bodies lies the posterior hypothalamic nucleus whose axons pass posteriorly into the brain-stem.

There is thus evidence for believing that at least three groups of efferent fibres arise from hypothalamic nuclei—one group arising in the supra-optic area of the hypothalamus, apparently innervating the posterior and intermediate lobes of the pituitary gland; a second group from some or all of the same nuclei and which pass into the brain-stem; and the third group from the posterior hypothalamus.

The afferent fibres to these various groups are not yet determined, but there is some experimental evidence which suggests some cortical control of the anterior hypothalamus and thalamic control of the posterior hypothalamus. It is unsafe, however, to presume specific fibre-tracts from the cortex or the thalamus in the present state of our knowledge.

It has been demonstrated by many observers that channels or vessels pass from the anterior lobe of the pituitary gland through the stalk of the infundibulum into the region of the tuber cinereum. Many observers, too, have observed so-called ' colloid bodies ' in the posterior lobe and in the stalk. These have been presumed to represent some secretion of the pituitary gland. Again, Cushing claims that there is evidence that pituitary secretion may reach the third ventricle by passing through the ependymal epithelium. The weight of evidence at the moment does suggest that some hypothalamic cells, probably those close to the ependyma, are influenced by chemical substances elaborated in the pituitary. Cushing's experiments on unanæsthetized humans, when he placed pituitary extracts in the ventricular fluid and observed very marked autonomic disturbances, tend to confirm the chemical activation of at least some hypothalamic nuclei.

Experimental work on the hypothalamus has consisted of stimulation of small areas electrically, the production of lesions of varying sizes, and the injection of various substances into the ventricular fluid. Various phenomena have been observed, and it is possible to suggest that there are certain areas which give rise to specific effects differing from those obtained from areas only a few millimetres distant. The difficulty inherent in all stimulation experiments must not be lost sight of—i.e., a stimulation point may be accurately localized by histological means, but the actual physiologically stimulated zone is not necessarily coincident. However, by repeated experiments and stimulation of numerous points it has been possible to form some conclusions about the functions of several areas. The method of studying the effects of lesions does not provide so accurate information. Instead of observing some ' defect ' in the functioning of the autonomic nervous system, the effects obtained may be due either to the irritation of the lesion or to the release of some other mechanism. For these reasons the effects of hypothalamic lesions require very careful analysis. The injection method has provided useful information about the pituitary-hypothalamus relationship—but has not assisted in the localization of function within the area.

An analysis of all the available evidence of experimental investigations on the hypothalamus confirms the view that the more posterior nuclei are related to the true sympathetic nervous system, i.e., on stimulation of this area the characteristic phenomena of sympathetic excitation may be observed : (1) Cardiac acceleration ; (2) Vaso-constriction of skin vessels ; (3) Rise in blood-pressure ; (4) Adrenalin secretion ; (5) Pupillo-dilatation, etc. These effects are not obtained on stimulation preceded by section of the hypothalamus at the level of the aqueduct of Sylvius and extending not more than 3 mm. from the middle line on each side. They are also abolished or lessened in magnitude by doses of the barbiturates. Ergotamine also prevents their appearance.

A careful study by Biggart of the condition known as diabetes insipidus has revealed the interesting facts that minute lesions of the nuclei close to the optic chiasma, or ligation of the pituitary stalk or its destruction by tumour formation, or lesions in the tuber cinereum itself, can give rise to the disease. There can be

little doubt then that the hypothalamo-pituitary nerve connections are essential for the production of the anti-diuretic hormone of the pituitary gland in normal amounts. The hormone finds its way into the blood-stream and produces its effects on the kidney directly.

Various workers have shown that stimulation of the more anterior regions of the hypothalamus cause effects similar to those brought about by stimulation either of the vagus or pelvic nerves. Tonus of the stomach and bladder are raised, while the reverse effects are obtained by stimulation of the posterior hypothalamus. Compared with the phenomena obtained by stimulation of the posterior hypothalamus, the effects observed are, as a rule, less marked and are obtained from a more circumscribed area. Stimulation of the more lateral nuclei has shown that both sympathetic and parasympathetic phenomena can be obtained from these cell groups. Owing to the great number of fibres which cross this zone, the localization of any specific function in it is not possible.

One of the most important complications following operative procedures in or near the third ventricle is hyperthermia. There can be no doubt that this is due to some disturbance of the normal activity of the hypothalamus. Animals in which the hypothalamus has been destroyed or which have been decerebrated are unable to maintain a normal temperature unless the environmental temperature is maintained at the same level as the normal body temperature. It is well known that the preservation of the posterior hypothalamus, the mamillary bodies, and the tuber cinereum in an otherwise decerebrated animal prevents any disturbance of the temperature control.

Three explanations of these phenomena are possible: (1) The temperature fall is due to increased heat loss; or (2) The temperature fall is caused by a diminished heat production; or (3) By both factors acting together. The balance of evidence seems to favour the second alternative.

It has been pointed out above that the posterior nuclei of the hypothalamus when stimulated cause an increased adrenalin secretion. Moreover, Schmidt has brought forward evidence which suggests that the perfusion of a muscle with small amounts of adrenalin causes a rise in its temperature. Such small doses of the drug produce dilatation of the muscular vessels simultaneously with constriction of those of the skin (Dale and Richards). Clark has shown that these effects are still present even when pressor effects on the blood-pressure are absent, and Gruber demonstrated that when pressor effects do occur the muscular responses are exaggerated.

It seems legitimate, therefore, to presume that the continuous release of small quantities of adrenalin (which release seems to be under hypothalamic control) is responsible for the production of the heat necessary to maintain body temperature, and, further, that the heat is produced in the muscles of the body. Simultaneous constriction of the skin vessels assists by lessening the surface heat loss. The automatic control of this heat production seems to be effected by the hypothalamus itself, as heating of the blood passing to the hypothalamus results in a fall in body temperature, and localized heating of the same region by small copper coils containing hot water or by minute electric heating elements show that the cells of the posterior hypothalamus are very sensitive to minute changes in temperature.

Clinical hyperthermia is probably due to increase of the normal heat production. The pale dry skin with gradually increasing temperature may be explained

by an increase of adrenalin secretion with or without a parallel rise in the blood-pressure. As the centres which may be over-active are those which are very sensitive to the depressing effects of the barbiturates, it may be worth while to attempt to treat cases of hyperthermia by barbiturates even to the point of deep anæsthesia for short periods.

This very brief summary of the evidence in favour of a central controlling mechanism or mechanisms for the autonomic nervous system would not be complete were one to omit reference to Claude Bernard's famous dictum that " the constancy of the internal environment is a condition of the free life." There is no doubt that without some method of stabilizing our ' milieu intérieure ' the life of free-moving and efficient organisms would be impossible. It seems at present that the hypothalamus must be regarded as the necessary controlling mechanism of the autonomic nervous system and perhaps for many of the endocrine glands.

THE TECHNIQUE OF SYMPATHECTOMY

By E. D. TELFORD

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THE more customary procedures of sympathectomy to-day are lumbar-cord ganglionectomy, cervico-thoracic-cord ganglionectomy, presacral neurectomy, and perivascular operations on the inferior mesenteric and renal arteries. To these we must add the wide resection of the left gastric artery as now practised for obstructive lesions of the cardia.

I do not propose to take up any time with the technique of these; they are on the whole simple and straightforward and have been very adequately described by many writers. I would only say that I have altered my earlier view on the best approach to the cervico-thoracic ganglion. I was originally an enthusiastic supporter of the posterior incision, but in the course of thirty-five of these operations I became increasingly dissatisfied with the method. Not only is the operation more mutilating, involving a more stormy convalescence, but the exposure of the ganglion is not always good because the root of the first thoracic nerve lies between the operator and his objective. I have recently done all cases by the anterior approach, which, if it be thoroughly practised, is easier and gives an excellent view of the ganglion and its connections.

I wish, rather, to talk of the relation of technique to results. I do not think that any operator who has had sufficient experience of sympathectomy and has followed up his cases for some years can regard the outcome of his work as entirely satisfactory. Whilst the results are on the whole good, sometimes dramatically so, some degree of relapse or partial failure is unfortunately too frequent. This is more especially true of the attempted denervation of the upper limb as practised for Raynaud's disease, acrocyanosis, and allied conditions.

A second point is that our technique to-day is too gross and mutilating. We do not know enough to be able to pick out just that part which we wish to destroy. We are obliged to do too much in order to ensure that we have done enough. A good instance of this is the way in which in denervation of the arm we present the patient with a quite unwanted Horner's syndrome. Animal experiments are here of very doubtful value, and our sympathectomies become actual experiments in human physiology. It is only by variations of technique that we can hope to explore.

What, then, is the relation of technique to success or failure in sympathectomy? In considering this I shall ask a number of questions the answers to which I do not know, but on which I am hopeful that this discussion may throw some light.

Incomplete technique is the obvious explanation of some failures. The surgeon has missed his objective or has merely traumatized the structures, producing a real but temporary result which soon vanishes with recovery from the injury. But relapse can follow the most skilfully executed operations, and we must seek other explanations.

Take, for instance, the striking fact that the results in the legs are consistently better and more complete than they are in the arms. Perhaps some local condition such as difference in normal vascular tone may have something to do with this, but one must ask what the difference is between pre-ganglionic and post-ganglionic section. In lumbar-cord ganglionectomy the section must be largely pre-ganglionic and for the area of sciatic innervation is probably wholly pre-ganglionic; the results here are good. On the other hand, the cervico-thoracic ganglionectomy is post-ganglionic for the arm; the results are often clinically disappointing. I have recently practised a technique which approximates the cervical operation more closely to the lumbar.

The stellate ganglion and upper portion of the thoracic sympathetic cord are exposed by the anterior incision. No attack is made on the ganglion itself. The white rami of the second and third thoracic nerves are divided and the cord itself is crushed and divided below the third thoracic ganglia. It is one of the major difficulties of sympathetic surgery that we know very little about the exact position of the cell-station at which the fibres of any one white ramus may end, but it is evident that a section such as I have described is to a large extent pre-ganglionic. It is too early to appraise the result of this method. It will take at least two years, but the immediate result is in all respects excellent, and Horner's syndrome is not produced.

The notoriously variable anatomy of the autonomic system will explain some failures of technique. D. Sheehan's careful dissections and drawings of twenty-five cervico-thoracic ganglia showed that no two were alike in pattern and that the locale of any given ramus varies within very wide limits. Kuntz's nerve, i.e., the direct contribution from the second thoracic ganglion to the plexus is not likely to escape the experienced operator, but is it not possible that alternative paths may exist? It has been shown that fibres may reach the plexus from the vertebral ganglia; is there any possibility of a route by which pre-ganglionic fibres to this ganglion may escape division?

The question of regeneration as an explanation of relapse must arise. It would appear from the work of various observers that sympathetic fibres have an uncanny power of regeneration even when barriers of fascia and muscle fibre have been interposed. These are, however, animal experiments, and it must be seldom that the opportunity arises to study the question of regeneration in the human subject. I had recently one such opportunity. Two years after I had removed the cervico-thoracic ganglion by the posterior approach, I obtained permission owing to an incomplete result to explore by the anterior route. The exposure was very good and it was possible to show, beyond doubt, that there had been not the slightest attempt at regeneration of the divided thoracic sympathetic cord.

D. J. Williams has demonstrated to me on several occasions in our Surgical Laboratory at Manchester very beautiful specimens of sympathetic cell-stations on the walls of cerebral arteries. This finding obviously raises the question whether similar stations in the peripheral circulation may explain the variable and incomplete results which occur from time to time.

The vexed question of the existence of a spinal parasympathetic supply must also come into the picture. Other muscular tubes are known to have a double supply; is it not possible that a similar arrangement obtains for the arterial wall? Kure and his Japanese collaborators claim evidence that there is such a peripheral

parasympathetic supply, but these views have not met with support from other workers. There exist in the posterior root of a spinal nerve a large number of fibres whose function is as yet unknown. At present one can only say that they may be "spinal parasympathetic" fibres. I believe that the surgeon would welcome this explanation because it would throw light on a number of post-operative clinical problems which remain at present without solution.

It is an every-day observation that the brightly injected and warm limb which follows at once on sympathectomy begins to lose its colour and heat in a few days. In my experience this interval is four to five days for the hand and eight to ten days for the foot. We should learn much if we could truly interpret this change. J. C. White claims that it marks the period after which the denervated vessel becomes hypersensitive to adrenalin. His experiments are brilliant and convincing, and, as White writes in a personal communication, if they are true they are going to make the treatment of Raynaud's disease more difficult than we had imagined.

It is possible that we have not attached sufficient importance to the essential automatism of plain muscle. In the gut, Vivaldes has shown the power of contraction of smooth muscle deprived of all nerve-supply. It is evident that although the autonomic system exerts a control over smooth muscle it is not the prime mover, and we have perhaps expected too much from section of its nerve-supply. Certain clinical observations lead one to think that it is possible that this automatic action comes into play after a period of shock due to the section.

Finally, some failures are, as in all surgical work, due to operating too late. The disease has induced secondary fibrotic changes, of themselves irrecoverable and quite enough to vitiate the results of sympathetic section. For example, the operation is likely to fail in advanced thrombo-angiitis obliterans where the vessels are transformed into fibrous rods, and in some cases of old-standing megacolon and achalasia of the œsophagus in which the original muscular mechanism has been largely supplanted by fibrous tissue.

These are a few of the questions which call for answer, and they will best be met by prolonged clinical observation on the sympathectomized patient. On the answers will depend the ultimate fate of operations on the autonomic system. My own impression, based on a close clinical observation of 150 cases of cord ganglionectomy during four years, is that, in certain directions, these operations will become one of the established procedures of surgery, but it may be that the ultimate field will be more restricted than that in which we are now working.

EXPERIMENTAL SURGERY

THE EFFECTS OF OBSTRUCTION OF THE URINARY TRACT, WITH PARTICULAR RELATION TO THE FORMATION OF STONES

By J. GRAY
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THAT pathological lesions in the urinary tract are more liable to occur in the presence of an obstruction than in the non-obstructed tract may be said to be almost axiomatic. At the same time they do not seem to be inevitable, and it is not always possible to say which is the primary effect, as in the case of hydronephrosis with stone formation. The following clinical case may be relevant as an illustration of this.

A Chinese patient, aged 30, was admitted for severe hæmaturia following a blow on the back with an iron bar. There was some fullness in the loin and rigidity of the abdominal wall. The diagnosis was ruptured kidney, and he was treated expectantly. A month later, as the urine still contained blood- and pus-cells, his urinary tract was investigated, disclosing the presence of a hydronephrosis and stone formation (*Fig.* 294). It is impossible to say in this case which was the primary factor—namely, did the hydronephrosis precede the stone formation or vice versa, and were either or both present before the injury, or did they develop as a result of it? In view of such considerations it was felt that it would be desirable to investigate the condition of the urinary tract in cases of obstruction, and, further, to see if in experimental obstruction stone formation was liable to occur.

FIG. 294.—Pyelogram showing renal calculi and hydronephrosis.

The obvious experiment was to ligature one ureter in a series of animals so that by this means the condition of the obstructed and unobstructed side could be investigated. This was accordingly carried out, the obstruction in 4 cases being partial and in the rest complete, and in both normal animals and those on a stone-producing diet as described in another article. The results may now be considered:—

Twenty-five rabbits were kept on normal diet with complete obstruction for a period averaging at least three months, but in some cases extending to six months

—no stone stone formation occurred. Thus there appears to be no tendency to stone formation in complete obstruction, presumably because the renal function is progressively diminishing.

Fifteen rabbits were put on a stone-producing diet (Ca and vitamin D) for a period of three months; stones occurred in 4. There was none in the normal kidney (*Fig.* 295). It was particularly noticeable that in no case where complete obstruction was present with extensive hydronephrosis did stones occur, but in the 4 cases where obstruction was slight and the hydronephrosis was not noticeable to the naked eye stones formed in all. It would appear from this that there is no tendency to stone formation (even on a stone-forming diet) unless a

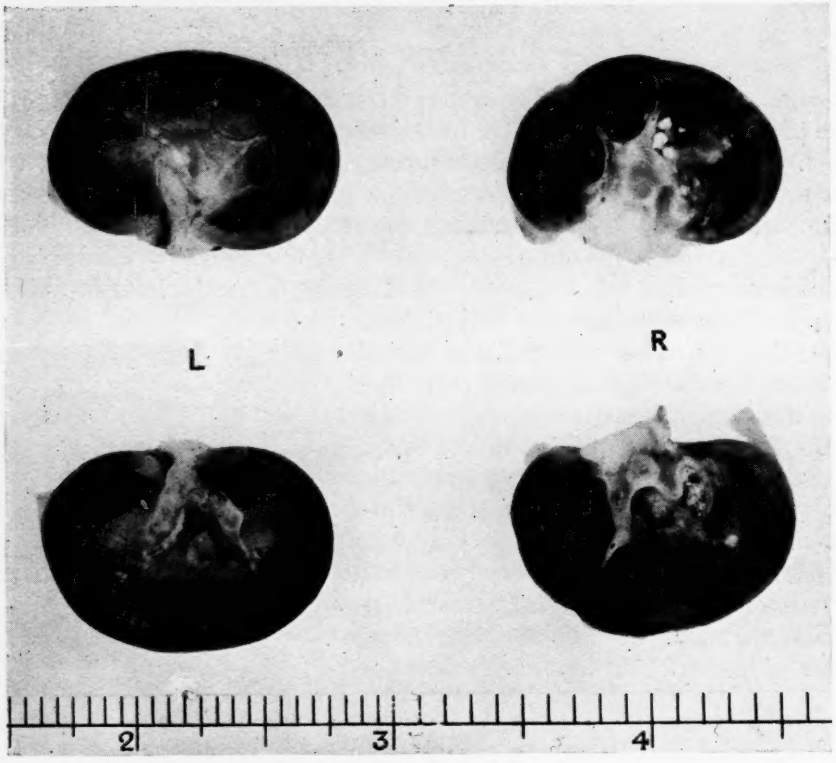

FIG. 295.—Renal calculi—experimental partial obstruction.

considerable degree of kidney function is present. The urine was examined systematically for pus- and blood-cells. In a few cases the latter were found, but in no case did the count of the pus-cells exceed 100 per 1 cm., or, in other words, there was no evidence to suggest that infection played any part in the process.

The points investigated were: (1) Renal blood-supply; (2) Tubular function; (3) Histology. These will be considered in order.

1. **Blood-supply.**—The following methods were used to investigate this: (*a*) Injection of carmine gelatin solution or Berlin blue according to the technique of Hinman and Lee Brown; (*b*) Arteriography or venography with 100 per cent

sodium iodide (*Fig.* 296); (*c*) Temperature estimations with a thermo-couple; (*d*) Direct measurement of blood-flow by simultaneous bleeding of both renal veins.

The carmine gelatin solution was frequently used after a preliminary two or three injections of intravenous trypan blue. In this way a combined picture showing the tubular function and the vascular supply was obtained. The estimation of the temperature change as a measure of the difference in blood-supply of the two sides was not very convincing, probably because sufficiently sensitive instruments were not available. The other methods need no comment.

All methods used demonstrated a marked diminution in the blood-supply in hydronephrosis.

FIG. 296.—Arteriography showing left-sided hydronephrosis.

2. **Tubular Function.**—This was investigated by giving intravital trypan in a dose up to 20 or 30 c.c. spread out over several days. This demonstrated very clearly the dilatation of the tubules and their loss of function (*Figs.* 297, 298).

3. **Histology.**—The features investigated were: (*a*) The condition of the pelvic epithelium; (*b*) The calcium content of the kidney (von Kossa's method);

FIG. 297.—Intravital trypan blue and carmine gelatin injection of vessels showing normal appearance.

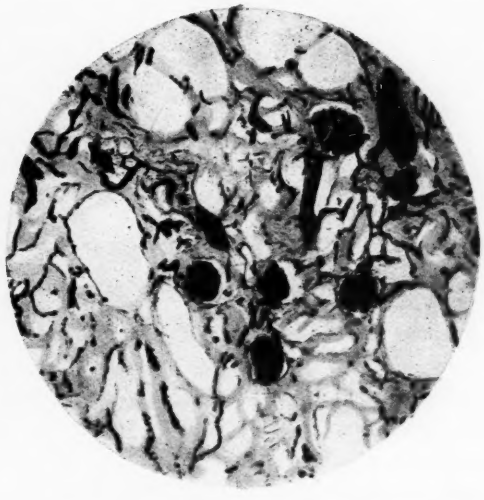

FIG. 298.—Intravital trypan blue and carmine gelatin injection of vessels showing effect of hydronephrosis.

(*c*) The presence of mucoid material. The findings in these points may now be considered.

a. The Pelvic Epithelium.—This was investigated by general observation with the hæmatoxylin and eosin stains and also by givng intravital trypan blue

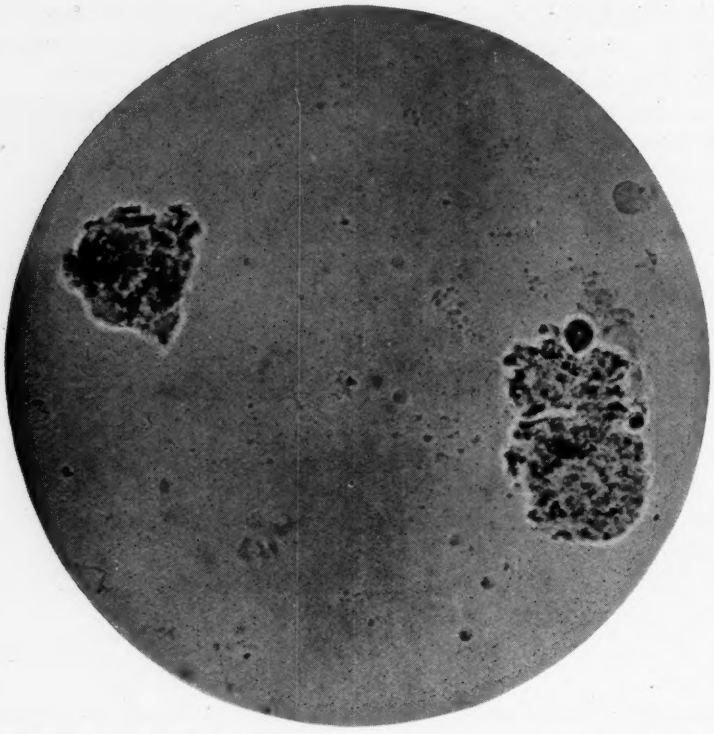

FIG. 299.—Epithelial scraping after intravital stain showing intracellular granules of the dye.

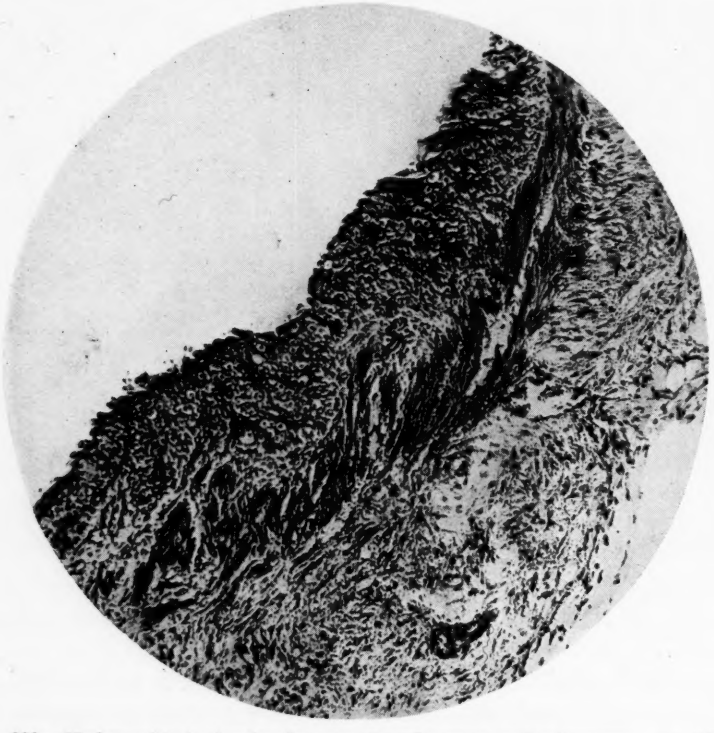

FIG. 300.—Hydronephrosis showing hypertrophy of mucosa and submucosa. (× 168.)

and examining scrapings of epithelial cells for granules of the dye. In the case of pathological changes intracellular granules may be seen (*Fig.* 299). This appears, however, to apply only to advanced pathological changes. In the early conditions no definite results were obtained. In the large majority of cases obvious changes in the epithelium were seen. The simplest of these was an irregularity and hypertrophy. In more advanced cases there was a tendency to metaplasia with change to the squamous type, and then desquamation was frequent. At the same time a hypertrophy of the submucosa was also noticed consisting in the laying down of fibrous or fibromuscular tissue. This is well shown in *Fig.* 300.

It can be concluded that severe obstruction, apart from any infection, produces definite pathological changes in the epithelium of the urinary tract.

b. Calcium Deposit.—The findings here were that in the cases of complete obstruction with hydronephrosis there was no tendency to deposition of calcium.

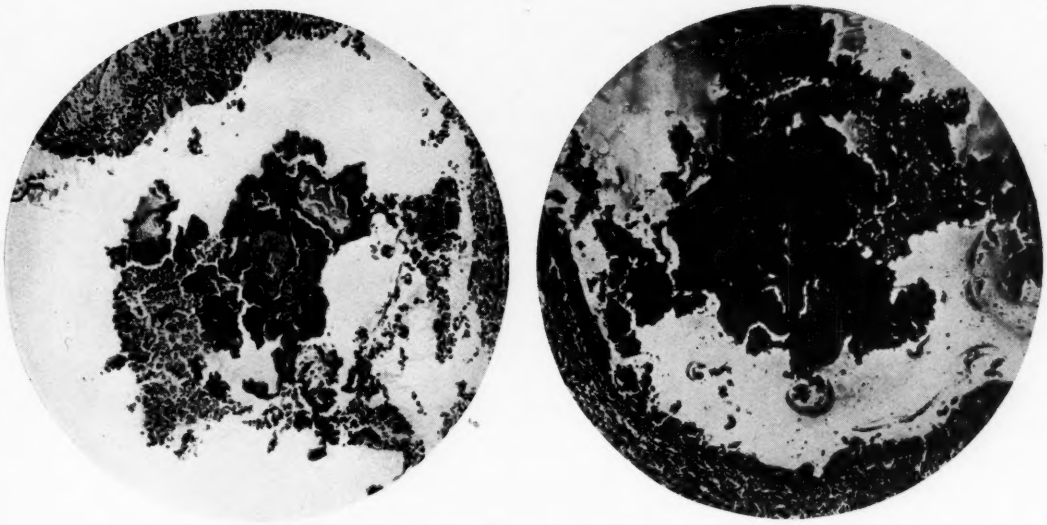

FIG. 301.—Showing deposit of calcium around desquamated epithelial cells. (× 140.)

This result was unexpected, but can perhaps be explained by the loss of function of the renal tubules. When the obstruction was partial only, then there was a marked tendency to the deposition of calcium and to stone formation. *Fig.* 301 in a partial obstruction shows deposition of calcium around the desquamated epithelial cells, forming a stone. The cause of the increase in calcium deposit is not certain. It may be associated with the decrease in blood-supply according to Leriche and Policard's theory, or it may be due to actual tissue damage and the liberation of fatty acids from which calcium soaps are formed. In the extensive hydronephrosis where tissue damage was great, however, calcium was not found. It was found chiefly in those cases where the damage to parenchyma was not very extensive, and then it was found scattered diffusely through the kidney as well as in the more damaged areas.

c. Mucoid Deposit.—This was strikingly increased as the result of obstruction and can be seen both in the dilated tubules and in the pelvis. *Fig.* 302

illustrates this finding. It is uncertain what relation this may have to stone formation when it occurs. In any case it was most marked in the completely obstructed cases where stone formation did not occur.

FIG. 302.—Hydronephrosis. Section shows mucin deposit. (× 142.)

SUMMARY

A series of rabbits with unilateral ureteric obstruction has been investigated. The obstruction was in four cases partial and in the others complete, and the period of obstruction varied from a fortnight to six months. It has been shown that a marked effect is produced upon the blood-supply, the renal tubules, and the pelvic epithelium. In addition a number of these rabbits were given a diet which has been found likely to give rise to stone formation. It appears from this that in complete urinary obstruction there is no tendency to stone formation, in partial obstruction there is a marked tendency. The two factors of importance in this seem to be an increased calcium content of the kidney and a pathological condition of the pelvic epithelium, so that calcium may be deposited around this as a nucleus.

This work was undertaken at the Henry Lester Institute as one of a series of investigations into the mechanism of stone formation. I am indebted to Dr. Gordon Thompson for helpful criticism, to Mr. R. V. Dent for the photographs, and to Mr. W. Henderson for the sections.

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THE EFFECT OF EXPERIMENTAL INTERFERENCE WITH THE BLOOD-SUPPLY OF THE KIDNEYS, WITH PARTICULAR REFERENCE TO THE FORMATION OF STONES

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THE basis of these experiments is the theory of Leriche and Policard, which states that deposition of calcium takes place in connective tissue of low metabolism if the blood-supply be diminished, particularly in the presence of hypercalcæmia. Clinically it has frequently been observed that renal calculi may develop in patients who have been recumbent for long periods. This has been noticed particularly in sanatoria for the treatment of bone and joint tuberculosis in children, where recumbency and sunlight are important features in the treatment.

Starting from this point of view, it was felt that if the blood-supply of the kidney were reduced experimentally, in the presence of hypercalcæmia, renal calculi should form. A series of 40 rabbits was used, 20 being on a normal diet and 20 on a diet calculated to produce hypercalcæmia. To effect this, lime (about 2·5 grm. per diem) and concentrated extract of vitamin D (radiostol, 1 drop per diem) were added to the diet. The urinary content of calcium and phosphates was estimated at regular intervals, and regular examination for pus-cells, blood-cells, and albumin was also carried out. It was found that on this diet the urine content of calcium was markedly increased and that of phosphates diminished relatively or absolutely.

With regard to the other part of the experiment, it was at first somewhat difficult to reduce the blood-supply without causing extensive damage to the kidney. However, eventually it was found that, with a little care, it was possible to separate the two terminal branches of the renal artery and ligature one close to the pelvis. When successfully carried out, the effect, noticed in a month or six weeks' time, was to produce a marked diminution in the size of the kidney, with, perhaps, a little scarring but otherwise no change detectable by the naked eye. When the branch ligatured was too large there was obvious necrosis of the renal parenchyma.

The results of these experiments may now be considered :—

Diet	Number Used	Stones Formed	Calcification
Normal	20	3 (15%)	6 (30%)
Normal, plus calcium and vitamin D ..	20	9 (45%)	5 (23%)

In no case did stones form in the normal kidney. Stones occurred on the ligatured side both on a normal diet and on the calcium-vitamin D diet, but in the latter case the number was three times as great (*Fig.* 303).

The duration of the experiments was about six weeks, although stones were sometimes demonstrable by X-rays in a month or even less. The stones were quite large and were always found in the pelvis or calices, never in the parenchyma.

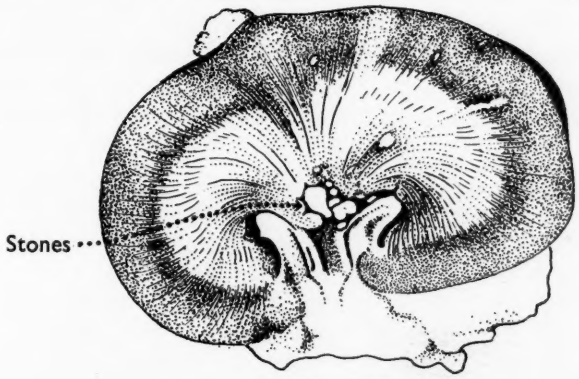


FIG. 303.—Renal calculi.

Apart from the regular examination for pus- and blood-cells, whenever possible the urine was cultured at the time the animal was killed. In only an occasional case was there any infection present, and there was nothing to suggest that this played any part at all in the pathology.

The following points were investigated in some if not in all cases: (1) Renal function; (2) Reaction; (3) Histology.

1. **Renal Function.**—This was investigated by giving 5 c.c. of 0·4 per cent indigo blue intravenously and watching the coloration of the kidney and the ureter. It was realized that this is a test of gross defect only, and as a matter of fact no definite difference could be detected in the two sides unless the damage to the kidney was obvious to the naked eye. The experiment was carried out on a dog to check the findings, but with the same result. There was no difference in the time of excretion of the indigo blue and no difference in the concentration of phenolsulphonephthalein. It is concluded that there is no gross defect in renal function as the result of this treatment.

2. **Reaction.**—In some cases both kidneys were split open while the animal was under the anæsthetic and the reaction of the pelvis to litmus paper tested. This was not done in every case as it was found to interfere with the subsequent histology. A sufficient number were examined, however, to demonstrate an obvious alkalinity of the ligatured side, while the normal side was neutral or often acid. In the cases where stones were present the alkalinity was more marked.

3. **Histology.**—The features investigated under this heading were as follows: (*a*) General appearance (hæmatoxylin and eosin) to show the effect of the ligature of a blood-vessel; (*b*) Special stain to demonstrate calcium (von Kossa's method); (*c*) Special stain to demonstrate mucoid material (Mayer's method); (*d*) Special attention was paid to the appearance of the pelvic epithelium in view of the fact that stones formed here—hæmatoxylin and eosin and also intravital trypan blue were used for this; (*e*) Intravital trypan blue was also used as a means of

investigating tubular function; (*f*) A number of sections of the renal pedicle were made to demonstrate nervous tissue or evidence of nerve degeneration. In all cases the normal kidney was stained in an identical way and examined on the same slide as a control.

In reviewing the findings it seems desirable to consider first the effect of ligature of the vessels, and then to see if any noticeable difference is present in those cases in which stone formation occurred. These points will be considered in order.

a. General Appearance.—When the amount of damage was slight, scarcely any detectable difference was present. As, however, the damage became more severe, areas of dilatation or even destruction of tubules could be seen very similar

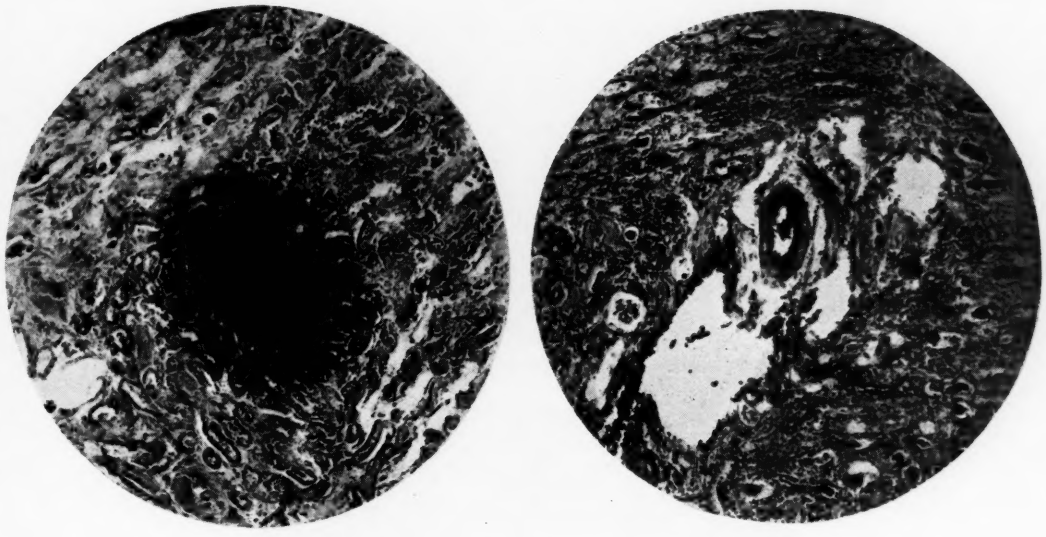
FIG. 304.—Section showing general histological appearance and tubular degeneration.

to the appearance in hydronephrosis (*Fig.* 304). When the damage was very severe an area of destruction was present with severe injury to the tubules, the glomeruli remaining relatively intact. Proceeding away from the most damaged area the tubules were found to be dilated and their epithelial lining hypertrophied. Foreign-body giant cells and areas of hæmorrhage were often seen. There was a marked infiltration with cells.

b. Calcium Stain.—As in the previous section, with minor degrees of injury due to deprivation of blood-supply it was not always possible to detect any difference in the calcium deposit in the two sides even though the kidney were definitely smaller to the naked eye. With severer grades of injury the calcium deposit was much more marked, and with very severe grades it was intense even though the

animals were on a normal diet. The calcium was deposited in the areas most damaged (*Fig.* 305).

c. Mucin.—The writer has not been able to find any information as to the formation of mucin in the urinary tract of rabbits and so has been compelled to rely on his own observations made on normal rabbits. It has been difficult to demonstrate mucin with certainty in the bladder, but in the kidney, either in the pelvis or in the tubules (*Fig.* 306), pink-staining material, presumably mucoid, has been demonstrated by means of Mayer's mucicarmine stain. On the whole, following the ligation of vessels the pink-staining material is more commonly found than on the normal side. Too much stress is not laid on these findings, and a bigger series is being undertaken.



A B

FIG. 305.—Sections showing: A, Calcium deposit; B, Giant-cell formation. (× 140.)

d. The Pelvic Epithelium.—In view of the observations noted in vitamin A deficiency described in the previous paper, particular attention was paid to this. The difficulty, however, was to be sure what could be regarded as definitely pathological. Unless the changes were gross, therefore, they were disregarded, although after a study of a large number of sections it was often felt that minor anomalies probably did represent early pathological lesions. It was common to notice obvious alteration in the appearance of the epithelium. The changes noted were hypertrophy and irregularity, often with marked desquamation (*Fig.* 307); occasionally areas of metaplasia were to be seen with change to the squamous type, but this was never as marked as in the vitamin-deficient animals. It would seem likely that metaplasia and keratinization represent the final stages of a series of changes which begin with hypertrophy, but that these experiments did not give rise to sufficient damage, or that observations were not carried out over a sufficiently long period to demonstrate the final stage.

In order to confirm the pathological nature of these changes intravital stains were used in 13 cases (a total of 30 c.c. of trypan blue being given intravenously

FIG. 306.—Section to show mucin in the tubules.

FIG. 307.—Desquamation and stone formation. Oxamide calculi showing epithelial change. (× 71.)

FIG. 308.—Hyaline of branch of renal artery. Stone formation beneath epithelial surface. (× 140.)

FIG 309.—Showing process of stone formation around the damaged epithelium. (× 56.)

over a period of several days). The animals were killed, and a scraping of epithelial cells obtained from the pelvic mucosa was examined fresh, in saline or glycerin, for intracellular granules (*see Fig.* 299, p. 454). This method was not very convincing, because if the epithelial cells were found to take up the granules (evidence of pathological changes), then the pathological appearance of the epithelium was obvious by ordinary staining methods. In the lesions which were felt to represent early changes no reliable information was obtained.

e. As a method of examining the tubular function intravital staining proved more useful. In this case the damaged epithelium failed to show the granules, presumably as it had lost its power of concentrating. It is noted that this reaction is the reverse of the reaction described in the previous section, where the damaged

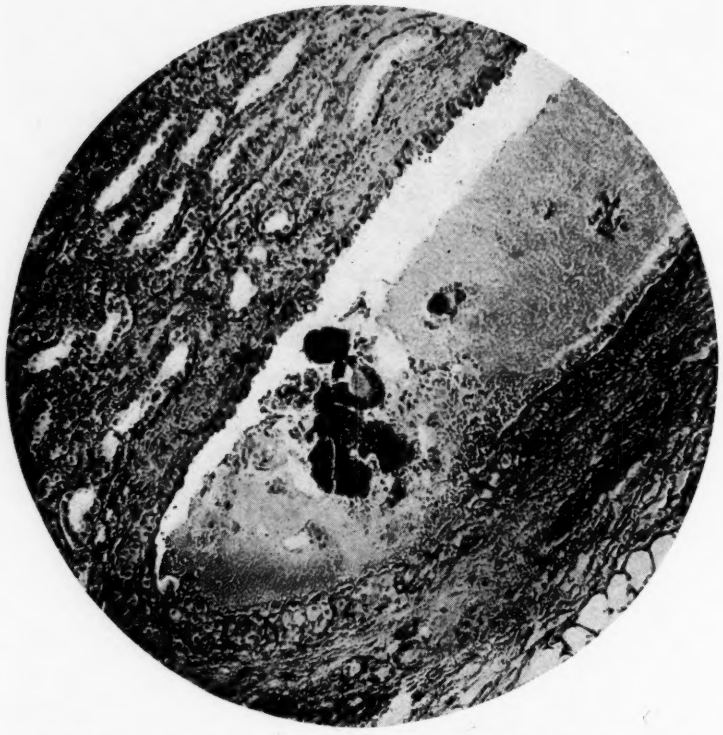


FIG. 310.—Oxamide stones in pelvis, showing also mucin deposit. (× 71.)

epithelium showed the granules. This suggests that (when there is a pathological lesion present) there might be some change of function in the direction of concentrating.

In 3 cases in this series of 13 some diminution of tubular function had occurred in the ligated side, but it was not very marked.

f. No evidence of nerve degeneration has been demonstrated in the renal pedicle and no changes in the suprarenals noted.

Cases where Stones were Present (12).—Here an abnormality of the pelvic epithelium was the rule. Marked desquamation was present in all cases, and frequently, if not always, the deposit of calcium in relation to these damaged

areas and around the desquamated epithelium was obvious. It seems clear from these appearances that stones are formed by deposition of calcium in relation to the injured epithelium (*Figs.* 308, 309).

Oxamide Feeding.—It was felt that it might be of interest to try other stone-producing diets in order to see if there were any predilection for the injured side —accordingly oxamide was used.

Ten rabbits were fed with oxamide, in addition to their normal diet, after preliminary ligature of a vessel in one kidney. In the kidney with a ligatured vessel five definite stones were formed (*Fig.* 310). They were quite large and hard.

In the normal kidney one formed definite stones, while in one other case one small concretion was present (presumably a stone). Occasionally fine granules of oxamide could be seen in the surface of the mucosa, but these occurred equally on both sides.

It appears from this series that oxamide stones also are more likely to form in the kidney the blood-supply of which has been reduced.

As a further variation of this experiment an attempt was made to slow up the blood-flow by partial obstruction of the renal vein. It was not found possible to do this without causing severe damage to the kidney, but in 1 out of 6 in this series the damage was less severe, and in this case a mass of large hard stones formed in the pelvis.

Fixation of the Kidney.—This was carried out in 5 animals by sewing the kidney capsule on to the last rib on the right side or to the posterior abdominal wall on the left side. At laparotomy, a month later, the kidney movements were markedly lessened and often imperceptible. No stones were formed in this series, neither was there any obvious difference in the calcium content of each kidney as determined by the histological method. It was concluded that there is no evidence that deficient movement in the kidney has any effect on its calcium metabolism.

The effect of urinary obstruction has also been investigated, and has been described in the previous paper.

SUMMARY AND CONCLUSIONS

The truth of Leriche and Policard's theory is demonstrated by this series of experiments. The two important factors in the production of stone seem to be :—

1. A dietetic factor, as, for instance, a calcium-phosphorus imbalance or excess of some foreign substance such as oxamide.

2. A local factor which leads to the precipitation of the stone-forming substances.

In view of the fact that the stones always form in the pelvis or calices it seems that a cavity is necessary. In all cases there was some abnormality of the epithelial lining, and frequently the stones could be demonstrated forming around desquamated epithelium. This suggests that an important factor in stone formation is an alteration in the epithelium which might act by producing variations in surface tension, or more directly by giving rise to desquamation, the dead epithelial cells then acting as a nucleus for the stone.

FIG. 311.—Keratinization in vitamin A deficiency. (× 140.)

FIG. 312.—Hyperplasia of pelvic epithelium and desquamation in vitamin A deficiency. (× 140.)

This idea is confirmed by two other series of experiments which were carried out :—

1. A series of animals on a vitamin A deficiency diet was observed. It is not intended to describe these here except to say that in all cases where stones were formed, changes in the epithelium were marked, and indeed this is an effect well recognized. Calcium could be seen deposited around the desquamated epithelium, forming stones. (*Figs.* 311, 312.)

FIG. 313.—Desquamation of epithelium following salicylic acid injection. (× 126.)

2. In this series and in another series of rabbits on this diet or being fed with oxamide no stones were found in the bladder. If, however, the vesical epithelium had been damaged previously by an injection of 0·5 c.c. of salicylic acid in 1–1000 alcohol solution, stones formed as follows (*Fig.* 313) :—

In a series of 26 fed on the lime and vitamin D diet—
13 preliminary salicylic acid injections—stones formed in 2.
13 no salicylic acid injections—stones formed in 0.

In a series of 10 fed on oxamide—
5 had preliminary salicylic acid injections—stones formed in 3.
5 had no preliminary salicylic acid injections—stones formed in 0.

Other factors which were noted were an alteration in the reaction and an increased production of mucoid material. It is quite possible that these might be of influence in the initiation of the process of stone formation.

This work was carried out at the Henry Lester Institute as part of a series of investigations into the mechanism of urinary stone formation. I am indebted to Dr. H. Gordon Thompson for helpful criticism, to Mr. R. V. Dent for the photographs, and to Mr. W. Henderson for the sections.

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SHORT NOTES OF RARE OR OBSCURE CASES

BILOCULAR STOMACH DUE TO HERNIA OF THE SMALL BOWEL THROUGH THE TRANSVERSE MESOCOLON

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Hernia of the intestine through the transverse mesocolon is rare, and in a recent paper Menegaux[1] was able to collect from the literature only 59 undoubted cases. It is, however, a condition with which surgeons should be familiar, for it is seldom diagnosed before operation and therefore presents itself unexpectedly; even when the abdomen is opened the true state of affairs may remain in doubt, a fact shown by two cases in which a laparotomy was undertaken and in which the hernia was discovered at the autopsy. When recognized, and except in cases of acute obstruction, the treatment is straighforward and the prognosis is good.

The first accounts were given by Loebl in 1844, Dittrich in 1847, Deville in 1851, and Treitz in 1857. All these dealt with post-mortem material, and it was not until 1902 that Akerman published the first description of an operation upon such a patient. His case had a gastric ulcer situated on the lesser curve of the stomach, and it was not till he started to do the posterior gastro-enterostomy that the hernia was discovered.

From time to time the recorded cases have been collected and analysed by various workers,[1-6] and the remarks at the end of this report are based upon the observations in these papers and upon the points which presented themselves in the present instance.

The interest of the present case lies in the fact that the hernia arose spontaneously and was unassociated with trauma or any previous operation, and that it has been successfully treated by surgery.

History.—The patient, a woman of 45, gave the following history. At the age of 16 she first began to suffer from intermittent attacks of colicky abdominal pain. The pain, which was sometimes severe, was felt in the lower part of the abdomen and round the umbilicus. After several years the attacks wore off and her general health improved.

Eight years later the pains returned and were aggravated by severe flatulence and vomiting; they were localized at this time to the epigastrium, but were unlike the pains associated with an ulcer in the stomach or the duodenum in that they bore no relation to food and were not relieved by drugs or diet. The vomiting became steadily worse over a period of months, and then, quite suddenly, all symptoms abated and the patient became normal except that she was prone to occasional attacks of flatulence.

She remained well for about twenty years, and then her troubles returned in the form of flatulence and diffuse abdominal pain. Both these symptoms increased in severity till she finally came to hospital to know if anything could be done for her. The attacks were now described as being most severe after a large meal; the symptoms would persist for about two hours and would gradually wear off, leaving a feeling of soreness in the epigastrium. She knew of no method of relieving the pain; she was never sick. There was no history of hæmatemesis or melæna.

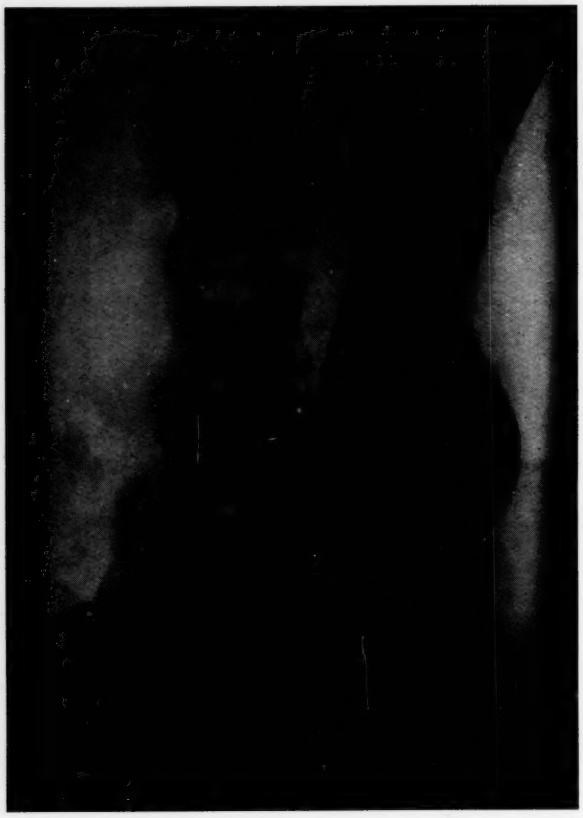

FIG. 314.—Before operation. X-ray of stomach taken directly after a barium meal. Report by Dr. Fildes: Grossly bilocular stomach without local tenderness. A spastic type of deformity presumably from a small ulcer not definitely seen.

ON EXAMINATION. — The patient's general condition was found to be good and there were no physical signs in the chest or the abdomen to account for her symptoms. As an out-patient a barium meal was arranged and the state of affairs shown in *Fig.* 314 was discovered. On this X-ray a diagnosis of bilocular stomach, due presumably to a lesser-curve ulcer, was made, although the history did not seem to fill the bill.

Two months later after a course of medical treatment a second X-ray was taken and the outline of the stomach was unchanged (*Fig.* 315). She was accordingly admitted for investigation.

A test-meal showed a normal quantity of hydrochloric acid both before and after histamine. The test for occult blood, which was returned as positive, was of doubtful value since she was found to be suffering from hæmorrhoids. Unfortunately a complete barium meal was never done.

OPERATION.—A laparotomy was advised and at the operation the explanation of her troubles was discovered. On opening the peritoneal cavity part of the pancreas, the small intestine, and the edge of the spleen presented; the stomach and transverse colon were not seen at this stage. She had a mass of calcified mesenteric glands binding the great omentum down to the right side of the pelvic brim. After freeing the omentum a hole in the transverse mesocolon about the size of a five-shilling piece was discovered, and through this three-quarters of the small intestine had passed into the lesser sac. There was no hernial covering derived from the mesocolon.

The gastro-hepatic omentum was practically non-existent and the coils of the small bowel had passed forwards between the lesser curve of the stomach on the left and the portal vein, hepatic artery, and the bile-duct on the right. In this way the body of the stomach was pinched between the intestines passing up into the lesser sac posteriorly and out over the anterior surface of the stomach in front of the transverse colon. The hernia was easy to reduce, and there were no adhesions in the upper part of the abdomen.

The mesocolon was repaired, but it was not possible to draw the edges of the gastro-hepatic omentum together since the vessels in front of the foramen of Winslow were almost completely exposed for the greater part of their course.

The stomach was then examined and was found to be divided into two distinct parts by a narrow isthmus. The site of the isthmus corresponded to the place where the coils of the small bowel had encircled the viscus. There was no evidence of ulceration or fibrosis in the stomach wall, and although it is possible that the organ might have readjusted itself in time it was thought that a gastrogastrostomy was necessary to ensure a fairway. The pylorus was examined and although the X-rays suggested the presence of pyloric stenosis nothing abnormal was found and it was deemed unnecessary to do a pyloroplasty.

FIG. 315.—Before operation. X-ray of stomach taken directly after a barium meal. This photograph was taken two months after that shown in *Fig.* 314.

At the conclusion of the operation the greater curvature of the stomach, and with it the spleen, had fallen back into their normal positions.

There was nothing in the vicinity of the transverse mesocolon to suggest the cause of the defect, and it was assumed to be congenital in origin. The pains which the patient experienced as a girl may have been due to tabes mesenterica, and the binding of the great omentum to the pelvic region probably occurred at this time and limited the space normally available for the jejunum. As the patient grew older the jejunum passed into the lesser sac and round the stomach, causing attacks of subacute obstruction characterized by flatulence and vomiting.

She made a good recovery from the operation and the X-rays taken three weeks and seven weeks later show that although some degree of pyloric stenosis

remains the stomach is otherwise quite normal (*Figs.* 316, 317). She states that her pains have been completely relieved and that she is now fit and well.

DISCUSSION

It may be of interest to give a brief summary of the main points which are known about herniæ through the transverse mesocolon.

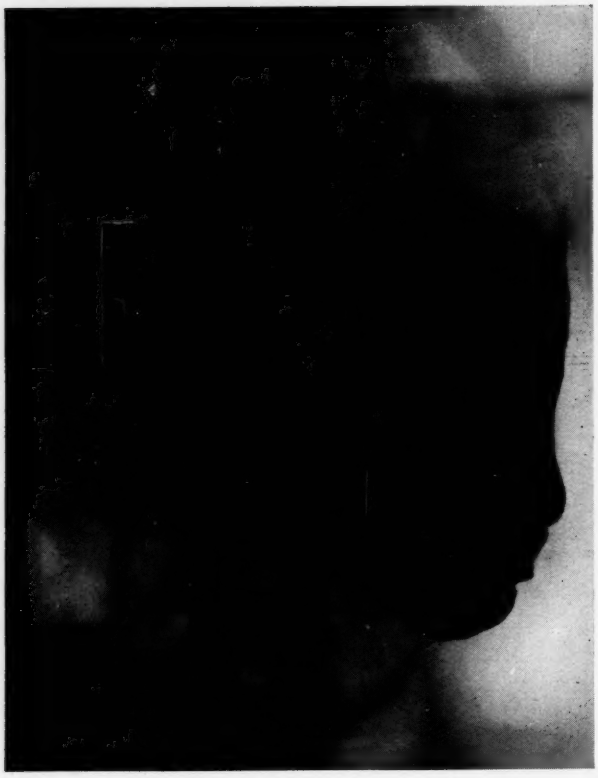

FIG. 316.—X-ray taken three weeks after operation. Barium meal showing six hours' residue in stomach. Gastro-jejunostomy functioning well, but appearance of pyloric stenosis.

They occur more commonly in women than in men and manifest themselves between the ages of 25 and 50.

Diagnosis is always difficult and the number of cases in which it has been made correctly before operation is very small.

The cases can be divided into four main clinical groups. In the first are those whose lesion is discovered post mortem and who, during life, have had no symptoms of the disease; in the second are patients who complain of vague digestive disturbances; the third group are those who have evidence of small bowel obstruction, which may be either acute or chronic; and the fourth are diagnosed as suffering from a gastric or duodenal ulcer or an hour-glass stomach.

The interpretation of X-rays, which alone can give the correct diagnosis before operation, is apt to be misleading, for on several occasions where a barium meal has been given an hour-glass stomach has been found. The clinician and the radiologist have been satisfied that this explained the symptoms, and consequently the passage of the medium through the small bowel was not investigated. On the other hand, a complete barium meal will demonstrate the loops of small bowel above the lesser curve of the stomach, and this is absolutely diagnostic.

The treatment is laparotomy with reduction and repair of the hernial orifice, and it is here that a knowledge of the various types of hernia which have been described may save the surgeon a great deal of trouble in working out the lie of the land, for on opening the abdomen the small bowel usually presents, and it may be difficult to find the stomach and transverse colon.

There are two types of hernia. The first has a sac formed from the thinned-out mesocolon. This is a rare condition and the hernia is usually small. The common variety has no sac and the two omental cavities communicate directly with each other.

It is usual for the small bowel to be drawn into the lesser sac, but cases are on record in which the stomach has passed downwards. It seems that in the majority of cases the small intestine is sucked up by the excursions of the diaphragm, and it is not uncommon for all the small intestine and even the cæcum to pass through the hole. In two cases the hernia recurred at operation as soon as it had been reduced, and it was only with difficulty that the bowel could be maintained in its anatomical position.

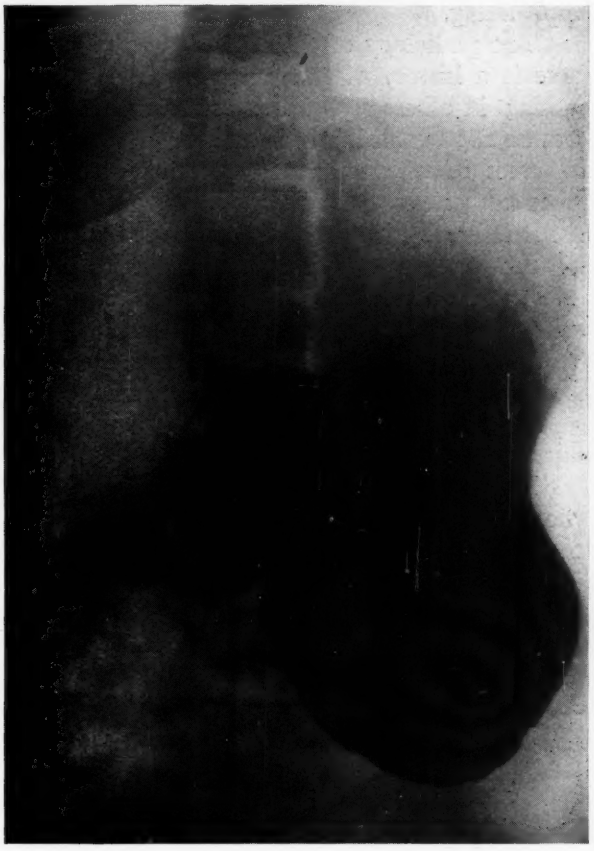

FIG. 317.—X-ray taken seven weeks after operation. Stomach rather dilated and to the left of the mid-line. Empties slowly via a deformed cap. Some degree of pyloric stenosis remains.

Except in the early cases the bowel does not remain in the lesser sac but pushes onwards and either comes through the foramen of Winslow (this is very rare) or else perforates the gastro-colic or the gastro-hepatic omentum. The latter is the common course, and, in the words of Menegaux, the small intestine "se répand alors en cascade devant l'estomac et le côlon transverse", and in so doing it compresses the stomach so strongly at the point where the mesentery rounds the lesser curve that the stomach is divided into two parts. In examining the recorded cases one finds that sometimes the hour-glass deformity is due to spasm and sometimes it is associated with a simple or malignant ulcer.

Unless strangulation has occurred reduction is always easy, for there are no strong adhesions and the hole is large. Practically the only cases in which adhesions have been described are those in which the transverse colon and the omentum have been involved as well as the small bowel. The flimsy texture of the transverse mesocolon presumably accounts for the rareness of cases that have been strangulated.

There is usually no difficulty in repairing the transverse mesocolon, but in almost all cases the colic vessels have been described as lying in the margins of

the hole and the sutures must be placed in such a way that the blood-supply of the colon is not disturbed. When it has been impossible to repair the defect by simple means the posterior aspect of the stomach has been used to stop the gap. This was the plan adopted by Mayo in the case he recorded.

It is important to remember that in at least 50 per cent of the cases a gastric or duodenal ulcer has been found, and this lesion may need surgical treatment after the hernia has been repaired. Other abnormalities, such as volvulus of the stomach, have been described, but are not present sufficiently frequently to need emphasizing.

The pathology of the condition remains a matter for debate. In many cases there is a history of trauma followed by the signs and symptoms of an internal hernia; in others a gastro-enterostomy has been done and the hernia has occurred because the mesocolon has not been closely sutured round the anastomosis. There are cases in which the only solution seems to be that the defect is congenital. Some authorities argue that the gastric ulcer is the important predisposing factor, but it is more likely that the ulcer is the result and not the cause of the hernia, for the peritoneum does not usually respond to inflammation by becoming fenestrated, the absence of adhesions is very definite, and the ulcer is usually quite a long way from the hernial orifice.

The number of cases which have been operated upon is small, but in the absence of acute obstruction the results of surgical treatment have been very satisfactory.

I am indebted to Mr. C. Max Page, Director of the Surgical Unit, under whose care this patient was admitted to St. Thomas's Hospital, for permission to treat and to publish this case, and to Dr. Fildes, who kindly provided the X-ray photographs.

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A MALIGNANT TUMOUR (SYMPATHICOBLASTOMA) OF THE SUPERIOR CERVICAL GANGLION

BY FRANK T. LAND

ASSISTANT SURGEON, GLASGOW EAR, NOSE AND THROAT HOSPITAL

SCOTT and Palmer (1932) have classified tumours arising in the sympathetic nervous system according to their degree of differentiation, thus following the scheme proposed by Bailey and Cushing (1926) for neoplasms of the central nervous system. The type most frequently encountered in the autonomic system is the ganglioneuroma, which is composed of mature ganglion cells and is usually a simple growth. In contrast with it at the other end of the scale is the highly

malignant sympathicoblastoma, a tumour formed by rapidly proliferating embryonic sympathetic cells. It occurs most frequently in infancy and early childhood, and usually originates in the suprarenal medulla. The sympathetic plexuses of the abdomen, thorax, or neck are only rarely the site of origin. The present case is an example of the last type.

HISTORY.—C. S., a boy aged 4 years, was brought to hospital in January, 1931, with the complaint of pain in the left ear of fourteen days' duration. It was not severe and was accompanied by slight otorrhœa. Soon after the onset the parents noticed a swelling below the left ear, and remarked on the impaired movement of that side of the face. Swallowing had occasionally been difficult, the attempt inducing spasms of coughing. Latterly the child's appetite had been poor and his sleep disturbed by earache. With the exception of slight rickets the previous health had been good, and there was no history of former ear trouble.

ON EXAMINATION.—The child was listless and inattentive: the temperature was sub-febrile. Facial paralysis of peripheral type was present on the left side. The pupils were markedly unequal, the left being contracted but reacting to light and in accommodation. The left anterior and posterior auricular glands were enlarged, while the jugulo-digastric group formed a mass about the size of a pigeon's egg below the tip of the mastoid process. The glands were fairly discrete and were not tender. There was no œdema over the mastoid, which was moderately tender at the posterior border and at the tip. The auditory meatus contained some pus, removal of which revealed what appeared to be granulation tissue obscuring the tympanic membrane. There was profound deafness on that side without loss in bone-conduction. Spontaneous vertigo and nystagmus were absent. The mouth and pharynx appeared to be normal, but the presence of pharyngeal anæsthesia could not be determined.

X-ray films of the mastoids showed loss of cellular definition and an irregular clear area below the antrum on the affected side.

At operation on the mastoid removal of a thin cortex revealed a uniformly whitish friable tissue, which almost entirely replaced the mastoid cells and extended into the auditory meatus, the digastric groove, and the posterior cranial fossa. As the appearance at this stage suggested an inoperable sarcoma radical operation was not attempted, but specimens were taken for histological examination. On receipt of Dr. Blacklock's report that the tumour was a highly malignant, undifferentiated sympathetic growth, deep X-ray therapy was instituted. One exposure of 600 r. over the region of the swelling resulted in considerable diminution in its size. A fortnight thereafter the tumour commenced to grow rapidly once more, and the child died with symptoms of meningitis six weeks later, i.e., ten weeks from the onset of the illness.

AUTOPSY.—Dr. Blacklock performed an autopsy and found a mass of tumour tissue in the neck, extending upwards from the region of the superior cervical ganglion. It was not encapsulated and had invaded the surrounding muscles. The internal carotid artery and the jugular vein were surrounded by the tumour tissue, which also enclosed the glossopharyngeal nerve, the pharyngeal branch of the vagus, and some cervical nerve-roots. Spreading upwards the growth had invaded the mastoid through the digastric groove. Where it had broken through the compact bone on the posterior surface of the petrous, small protuberances

were formed under the dura. At no place, however, had the latter been penetrated. The jugulo-digastric lymph-glands were enlarged, discrete, and whitish in colour. No other secondary growths were found, and both suprarenals were normal both on naked-eye and microscopic examination. Death had occurred apparently from basal meningitis, which was the only other lesion present.

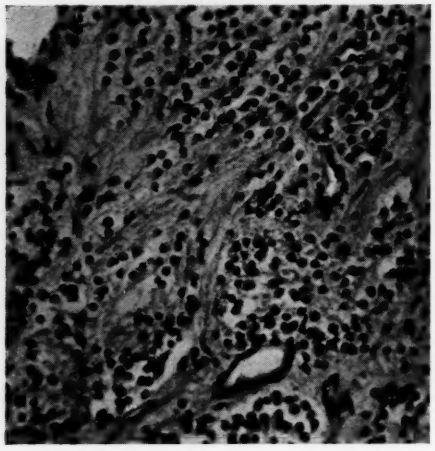

FIG. 318.—Section of tumour from region of superior cervical ganglion showing masses of small darkly-staining cells and fairly abundant fibrils. (*Hæmatoxylin and eosin.*) (× 200.)

Portions of the tumour tissue from the region of the superior cervical ganglion and from the mass in the temporal bone were examined microscopically. The growth was almost entirely composed of small round cells with deeply staining nuclei and scanty cytoplasm. Some larger cells with more abundant cytoplasm and vesicular nuclei were found, but no mature ganglion cells were discovered. After a careful search of a number of sections imperfect pseudo-rosettes were observed, but mitotic figures were scanty. Fibrillar material was present scattered irregularly throughout the tumour and was most plentiful in the specimens from the mastoid extension (*Fig.* 318). It stained yellowish in iron hæmatoxylin and van Gieson preparations, and greyish-black by the Cajal method. The cervical glands in the neighbourhood of the tumour were extensively invaded.

DISCUSSION

In a young child the clinical syndrome characterized by otorrhœa of painless onset, mastoid tenderness, glandular enlargement, and facial paralysis is almost invariably the result of tuberculous infection of the middle-ear and mastoid. In the present case, however, the additional features of myosis and dysphagia, attributable to involvement of the sympathetic, vagus, and glossopharyngeal nerves, suggested a more extensive lesion, probably of malignant nature. The histological appearances proved to be those of a sympathicoblastoma, only slightly differentiated. It seems reasonable to presume that it arose in the superior cervical ganglion. The position and direction of spread of the tumour, and the absence of any other nearby source of sympathetic cells, makes it tolerably certain that it originated in, rather than invaded, the ganglion. Burghard (1900) found that operative removal of the superior ganglion produced, in addition to myosis, unilateral flushing of the face and intense and persistent headache. Of these features myosis alone occurred in our case.

Excluding those arising in the medulla of the suprarenals, malignant tumours of the autonomic nervous system have been very infrequently recorded. In 1932 Scott and Palmer reported a case of intrathoracic sympathicoblastoma, and made an extensive survey of the literature. They found references to 31 cases, in the greater number of which the tumour affected the abdominal plexuses. Martius

(1913) recorded the post-mortem findings in the case of a child of 2½ years who was operated on for the relief of dyspnœa. The tumour, a sympathicoblastoma, originated in the middle cervical ganglion and compressed the trachea. The histological features of a similar rapidly growing neoplasm in an infant of 9 months have been described by Stewart (1919). Arising in the upper cervical region the growth bulged into the pharynx and was thought at first to be an abscess. Indeed, a quantity of pus was released by incision. Rapid growth continued and an attempt at removal was unsuccessful, the child surviving for only a few hours. An autopsy was not permitted. Von Fischer (1922) recorded a rather more differentiated tumour occurring in the neck of a still-born child. Capaldi (1927) described the case of an adult in whom neoplasms of the inferior cervical ganglion and the adrenal medulla invaded the vertebral canal causing paraplegia. Shirai (1933) has recorded an instance, also in an adult, of a tumour of the cervical sympathetic with metastases in the mucosa of the stomach.

When the cranial bones are invaded by sympathetic-cell tumours it is almost invariably in the form of metastases of a primary suprarenal growth (Blacklock, 1934). The orbit is then commonly affected and exophthalmos a striking feature (Greig, 1929). Tileston and Wolbach (1908) and Blacklock (1934) have recorded instances where the abdominal tumour was not apparent for some weeks after the appearance of cranial metastases. In the present case we assumed that there was probably a primary adrenal growth, and so we were discouraged from persisting with radiation therapy despite its temporarily favourable effect.

I have pleasure in thanking Dr. J. W. S. Blacklock for his reports on the histological and post-mortem examinations, and for the illustration.

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REVIEWS AND NOTICES OF BOOKS

Clinical Pathology of the Jaws: with a Histologic and Roentgen Study of Practical Cases. By KURT H. THOMA, D.M.D., Charles A. Brackett Professor of Oral Pathology in Harvard University, etc. Large 8vo. Pp. 643 + xii, with 423 illustrations. 1934. London: Baillière, Tindall & Cox. 38s. net.

IN the Preface the author writes, "In many respects the jaws have been the 'no man's land' of the human body. They are of no particular concern to the average physician, because treatment almost always involves a dental problem and he has no desire to interfere with the highly specialized field of the dentist; conversely, the dentist primarily treats the teeth and has little experience in generalized diseases affecting the maxilla and the mandible." Surgeons and dentists will agree with this statement and will welcome this compendious volume as a serious and painstaking attempt to present an up-to-date account of what is known of the pathology and clinical aspects of diseases of the jaws.

Not only does the author include malformations, fractures, infections, cysts, and neoplasms of the jaws, but he has sections devoted to those changes induced by endocrine disturbances, nutritional disturbances, and general diseases of uncertain etiology, so that the volume contains a very complete account of this subject.

In our opinion the best part of this work is that which treats very fully of the various cysts that occur here; in this, as in the other sections of the book, the author not only mentions cases that he has seen personally, but has also ransacked the literature of the subject and has searched the medical museums for specimens to illustrate his thesis. The numerous illustrations are excellent; the coloured microphotographs, of which we should like to have seen more, are beautifully reproduced; the X-ray reprints, as so often happens, are rather a mixed lot, and some of them are not very helpful to the reader.

There is an excellent bibliography, though with what to us appears to be an astonishing exception; it is obvious that the author is intensely interested in the pathology of bone with its puzzling sequelæ of increase and decrease of calcification, yet he does not seem to be acquainted with the recent work of Leriche and Watson Jones; at any rate, we can find no reference to it. We make the modest suggestion that, when a second edition of this work is called for, this omission should be rectified.

We believe this work will become the standard book of reference on the pathology of the jaws and we cordially commend it to the attention of surgeons and dentists.

The Story of the Middlesex Hospital Medical School. By H. CAMPBELL THOMSON, M.D. (Lond.), F.R.C.P., Consulting Physician to the Department for Nervous Diseases, the Middlesex Hospital, etc. Large 8vo. Pp. 182 + xiii. Illustrated. 1935. London: John Murray. 10s. 6d. net.

THE story of the Middlesex Hospital Medical School is told well and pleasantly by Dr. H. Campbell Thomson, Consulting Physician to the Charity and a former Dean of the School. It is written on the occasion of the hundredth anniversary of the foundation of the Medical School.

The Hospital began in a small way in the middle of the eighteenth century and soon became a centre for students working at the Hunterian School. The clinical teaching, at first quite informal, became systematized when Sir Charles Bell, who had bought the Windmill Street School, was elected Surgeon to the Hospital. Students from his school followed him to the Hospital, and so long as he remained in London they attended in considerable numbers. When he left, the Middlesex Hospital staff established a proprietary school on the lines then usual. It languished for some years, but was reorganized and made to flourish by a strong medical and surgical staff aided by a succession of self-sacrificing deans. The school was united with the Hospital in 1896, and from that time to the present has gone forward steadily to become, as it now is, one of the great teaching centres in London.

Dr. Campbell Thomson tells of all the changes, modestly omitting mention of the share he himself took in them. He gives an account of the great physicians and surgeons who were on the staff, pointing out that Dr. William Hunter was never officially attached to the Hospital, though he once acted as locum tenens for the man-midwife. There is, too, an account of the life led by medical students in the middle of the last century, showing that Dick Swiveller was hardly a caricature and might as easily have been a student at the Middlesex as at Guy's. There are many good illustrations.

King's and Some King's Men. Being a Record of the Medical Department of King's College, London, from 1830 to 1909, and of King's College Hospital Medical School from 1909 to 1934. By H. WILLOUGHBY LYLE, M.D., F.R.C.S., Fellow of King's College, London; Dean Emeritus of King's College Hospital Medical School, etc. Royal 8vo. Pp. 613 + x. Illustrated. 1935. London: Humphrey Milford. 25s. net.

THIS volume, which Mr. Willoughby Lyle has entitled *King's and Some King's Men*, has an especial interest for surgeons. It is a history of the medical department of King's College, London, from its foundation in 1830 to 1909. During that period J. Moncrieff Arnott, Joseph Henry Green, Sir John Simon, Richard Partridge, Sir William Fergusson, Henry Smith, John Wood, Lord Lister, and Watson-Cheyne had been members of the surgical staff. Sir William Bowman, beginning life as a physiologist and general surgeon, set the tradition of cultured ophthalmic surgery which has been so successfully followed by Mr. Willoughby Lyle himself. It is not surprising that with such masters the Hospital formed a true nursing mother for its surgical pupils. Well trained, they went to all parts and did much good work in advancing surgery. Pridgin Teale at Leeds, C. P. Childe at Portsmouth, Johnson Smith at Greenwich, Nottidge Macnamara at Calcutta, McDougall, Bishop of Labuan and Sarawak, in the Far East, Christopher Heath, John Whitaker Hulke, Edward Bellamy, Thomas Bond, Thomas Nunn, George Lawson, and Sir John Tomes in London. Sir William Bowman's teaching was reflected in Richardson Cross of Bristol, in Edward Nettleship, George Critchett, and Gustavus Hartridge. All were great men in their different spheres, and all are given their due meed of praise by Mr. Willoughby Lyle.

The book is a mine of information and is well worth reading as the story of the progress of an institution from very small beginnings to its present position in the world of English medicine. The book is well illustrated and there is an excellent index.

Surgical Diseases of the Chest. By EVARTS AMBROSE GRAHAM, A.B., M.D., F.A.C.S., Professor of Surgery, Washington University School of Medicine, St. Louis; JACOB JESSE SINGER, M.D., F.A.C.P., Associate Professor of Clinical Medicine, Washington University School of Medicine, St. Louis; and HARRY C. BALLON, M.D., C.M., F.A.C.S., formerly Assistant Professor of Surgery, Washington University School of Medicine, St. Louis. Large 8vo. Pp. 1070, with 637 illustrations. 1935. London: Henry Kimpton. 65s. net.

THE publication of a book on thoracic surgery by such authorities as Graham and his co-workers will inevitably interest those who have attempted to follow the rapid advances in this increasingly important branch of surgery. These authors indicate that an appeal to the physician seems even now to be particularly desirable, as there is still an insufficient appreciation on the part of medical men in general of the help in many conditions which a surgical attack offers. A perusal of the table of contents would certainly lead one to believe that there are few chest diseases, either of themselves or in their complications, in which surgical measures have not been attempted. The nature of their undertaking is best illustrated by the extensive bibliography appended at the end of each chapter, subdivided into corresponding sections to the text. This bibliography amounts in total to almost one hundred pages, and as the great majority of references refer to papers published in recent years, accounts for the difficulty of keeping up to date a book which necessarily takes several years to complete. In spite of these obvious difficulties, or perhaps because of them, the authors are the more to be congratulated.

The first chapter, on physiological considerations of importance to the thoracic surgeon, largely embodies the previously published views of Graham which are now widely accepted, and this section merits careful consideration from all surgeons who are called upon to treat patients with any intrathoracic condition.

The short section upon anæsthesia is frankly disappointing and well below the general standard of the book. A wide discussion upon more recent forms of anæsthesia and the question of premedication was to be expected.

The surgery of the heart, pericardium, and large vessels occupies nearly eighty pages, and a full account is given of every condition amenable to surgical methods. The recent work on angina pectoris by sympathectomy, alcohol injection of the sympathetic, and by thyroidectomy receives consideration.

Pulmonary suppuration apart from bronchiectasis, carcinoma of the bronchi, the œsophagus, and diaphragm, each have chapters devoted to their special pathological conditions. A separate chapter by David H. Ballon on diseases of the trachea and bronchi endoscopically considered, although well written and illustrated, has resulted in a somewhat unnecessary overlapping and repetition of conditions previously or subsequently considered.

The last portion of the book is devoted to the treatment of pulmonary tuberculosis by artificial pneumothorax, oleothorax, cauterization of adhesions, and the recognized purely surgical measures of phrenicectomy, plombage, and thoracoplastic procedures. The latter in view of their great importance would appear to be much less fully discussed than cardiovascular conditions, in which surgical measures are much less frequently attempted or required.

Unquestionably the best section in the book is that devoted to bronchiectasis. This condition is considered from every aspect—etiology, pathology, diagnosis, prognosis, and treatment all being considered in detail. In view of changes during the last two years, an unduly pessimistic view of the radical treatment by lobectomy is indicated. This impression is somewhat diminished, however, by perusal of the preface to the book.

Descriptions of illustrative cases throughout add considerably to the value of the text, and the inclusion of a large number of illustrations, diagrammatic drawings, and radiograms is to be commended. To those without experience in thoracic surgery a measure of dogmatism is often advisable in such a text-book, but this may well be a fault in a subject where changes are so rapid.

There can be no doubt that this book fulfils an essential need at the present time, will repay reading, not only by surgeons but by physicians, and as a book of reference is invaluable.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]

La Maladie des Pêcheurs d'Eponges nus. By SKÉVOS ZERVOS. Large 8vo. Pp. 29. Illustrated. 1935. Paris: Libraire J.-B. Baillière et Fils. No price given.

Estudos cirurgicos (First Series). By ENRICO BRANCO RIBEIRO (Santa Catharina). Large 8vo. Pp. 241. Illustrated. 1934. Sao Paulo, Brasil: Sociedade Editora Medica Limitada. No price given.

Diseases of the Liver, Gall Bladder, Ducts and Pancreas: their Diagnosis and Treatment. By SAMUEL WEISS, M.D., F.A.C.P., Clinical Professor of Gastroenterology, New York Polyclinic Medical School and Hospital, etc. With a chapter by J. P. GRANT, M.D., F.A.C.S., M.R.C.S., and A. J. QUIMBY, M.D., F.A.C.R. Imperial 8vo. Pp. 1099 + xxviii, with 358 illustrations and 6 coloured plates. 1935. New York: Paul B. Hoeber Inc. $10.00.

A Guide to the Surgical Paper: With Questions and Answers. By R. J. MCNEILL LOVE, M.S. (Lond.), F.R.C.S., Surgeon, Royal Northern and Metropolitan Hospitals, etc. F'cap 8vo. Pp. 78. 1935. London: H. K. Lewis & Co. Ltd. 5s. net.

The Theory and Practice of Anæsthesia. By M. D. NOSWORTHY, M.A., M.D., B.Ch. (Cantab.), Anæsthetist to Westminster Hospital, etc., with a Foreword by I. W. MAGILL, M.B., B.Ch. (Belfast), Anæsthetist to Westminster Hospital, etc. Crown 8vo. Pp. 223, with 35 illustrations. 1935. London: Hutchinson Scientific. 12s. 6d. net.